PHASE I

Geology, Energy, and Mineral (GEM) Resource Evaluation of Lava GRA, Idaho, including the Cedar Butte (33-4) and Hell's Half Acre (33-15) Wilderness Study Areas

Bureau of Land Management
Contract No. YA-553-CT2-1039

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ANCHORAGE, ALASKA
SEPTEMBER 1983

WGM INC.
MINING AND GEOLOGICAL CONSULTANTS

EXECUTIVE SUMMARY

The Lava Geology, Energy, and Mineral Resource Area (GRA) is located in southeastern Idaho in Bingham and Bonneville Counties. The GRA contains two Wilderness Study Areas (WSAs): (1) Cedar Butte (33-4) WSA and (2) Hells Half Acre (33-15) WSA.

Bedrock in the Lava GRA consists of Tertiary to Holocene basalt flows and minor amounts of rhyolite. The two WSAs encompass the area covered by the most recent lava flows, the Cerra Grande lava field and the Hell's Half Acre lava field.

A modest amount of geologic data is available for the area, but there is little geochemical data available and scant information upon which to draw conclusions on potential hydrocarbon resources. There is fairly good data available concerning low/intermediate temperature geothermal resources.

The geologic terrane is not favorable for the formation of metallic and most non-metallic mineral deposits or hydrocarbon resources. The area has a production history of slab lava for decorative stone, of cinder rock, and sand and gravel. Although specific data is very limited, moderate potential probably exists for the occurrence of high temperature geothermal resources. A summary of the GEM resource classification for the WSAs is shown in the following table.

SUMMARY OF GEM RESOURCES

CLASSIFICATION FOR THE CEDAR BUTTE AND HELLS HALF ACRE

WILDERNESS STUDY AREAS

	Classification
1. Locatable Resources	
a. Metallic Minerals	1C
b. Uranium and Thorium	1C
c. Non-Metallic Minerals (except Slab Lava)	1C
Slab Lava	4D
2. Leasable Resources	
a. Oil and Gas	2B
b. Geothermal -	
High Temperature Resources	2A-3A
Low/Intermediate Temperature Resources	2B
c. Sodium and Potassium	1A
d. Other	2A
3. Saleable Resources	4D

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d. Other	2A
3. Saleable Resources	4D

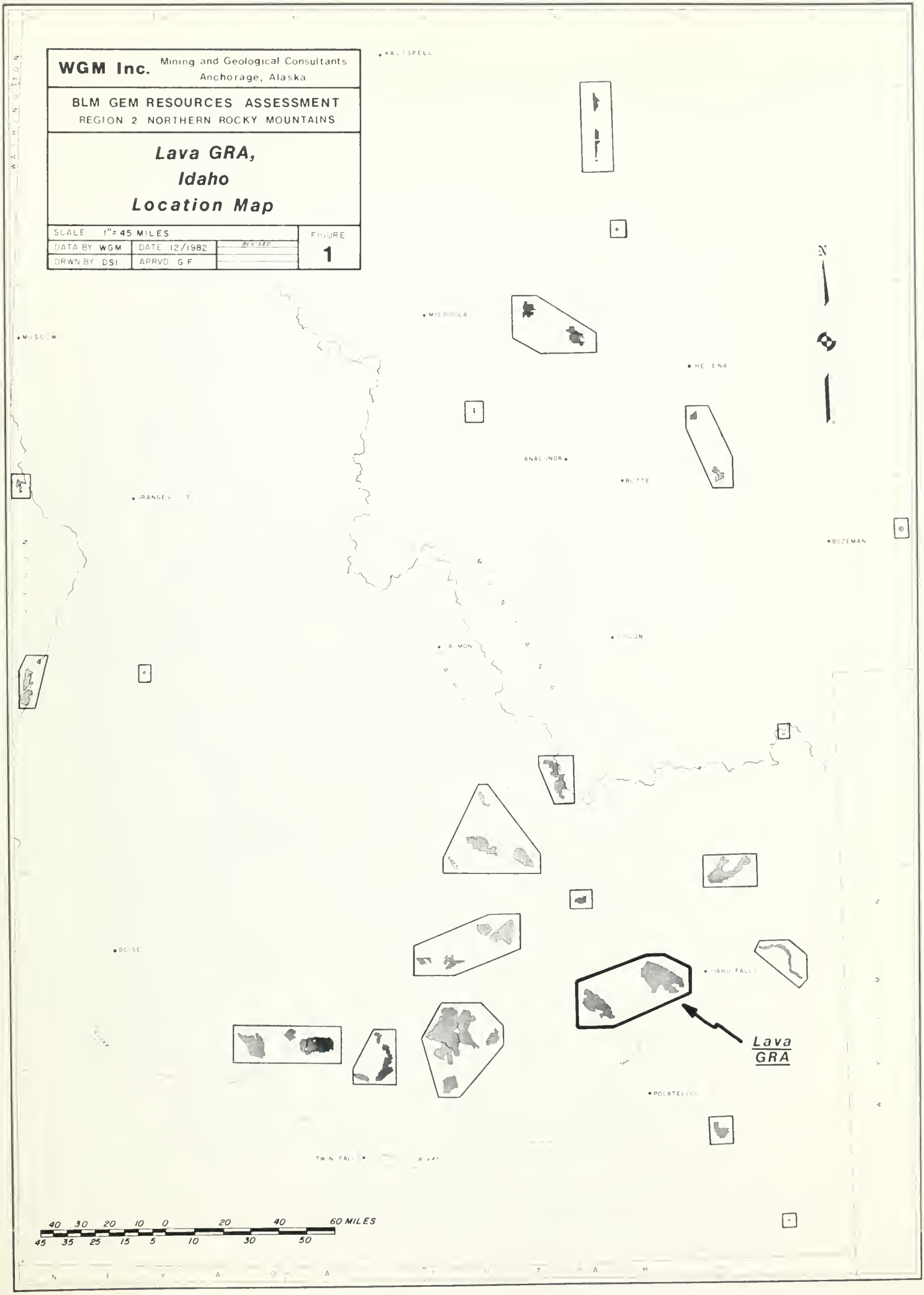
LAVA GRA, IDAHO

1.0 INTRODUCTION

The Bureau of Land Management has adopted a two-phase procedure for the integration of geological, energy and minerals (GEM) resources data into the suitable/non-suitable decision-making process for Wilderness Study Area (WSAs). The objective of Phase I is the evaluation of existing data, both published and available unpublished data, for interpretation of the GEM resources potential of the WSAs. Wilderness Study Areas are grouped into areas based on geologic environment and mineral resources for initial evaluation. These areas are referred to as Geology, Energy, Mineral Resource Areas (GRAs).

The delineation of the GRAs is based on three criteria: (1) a 1:250,000 scale map of each GRA shall be no greater than 8½ x 11 inches: (2) a GRA boundary will not cut across a Wilderness Study Area; and (3) the geologic environment and mineral occurrences. The data for each GRA is collected, compiled, and evaluated and a report prepared for each GRA. Each WSA in the GRA is then classified according to GEM resources favorability. The classification system and report format are specified by the BLM to maintain continuity between regions.

This report is prepared for the Bureau of Land Management under contract number YA-553-CT2-1039. The contract covers GEM Region 2; Northern Rocky Mountains (Fig. 1). The Region includes 50 BLM Wilderness Study Areas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Mining and Geological Consultants
Anchorage, Alaska
BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS
Lava GRA,
Idaho
Location Map
SCALE 1"= 45 MILES
DATA BY WGM
DATE 12/1982
REVISED
DRWN BY DSI
APRVD G F
FIGURE
1
ANACONDA
BUTTE
BOZEMAN
BOISE
Lava
GRA
40 30 20 10 0 20 40 60 MILES
45 35 25 15 5 10 30 50

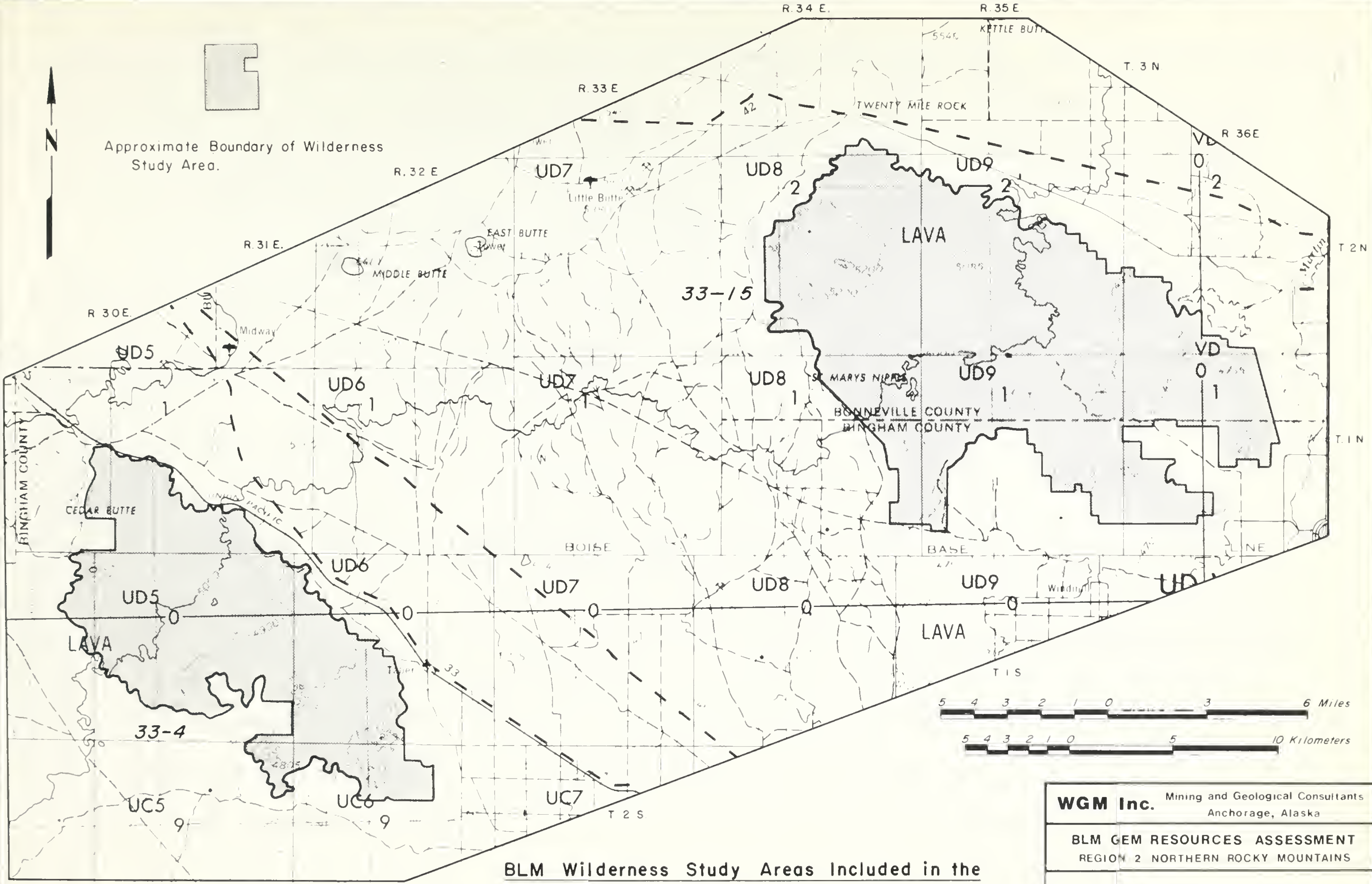
totalling 583,182 acres. The WSAs were grouped into 22 GRAs for purposes of the Phase I GEM resources evaluation.

1.1 Location

The Lava GRA is located in southeastern Idaho in Bingham and Bonneville Counties. The GRA encompasses roughly 800 square miles of the Snake River Plain in Ts.1-3N. and Ts.1-2S., Rs.30-36E. (Fig. 2). The Lava GRA is administratively within the Big Butte Resource Area of the Idaho Falls BLM district. The GRA contains two Wilderness Study Areas (WSAs): (1) Cedar Butte (33-4) WSA totalling 35,700 acres and (2) Hell's Half Acre (33-15) WSA totalling 66,200 acres.

1.2 Population and Infrastructure

Idaho Falls (pop. 39,590) is six miles east of the eastern Lava GRA boundary and Blackfoot (pop. 10,065) is 10 miles southeast of the GRA. Within the borders of the GRA are the small communities of Atomic City and Taber. Two highways extend through the GRA : (1) U.S. 26 which runs southeast-northwest through the central part of the GRA and (2) U.S. 20 which is located along the northern boundary of the GRA. A branch of the Union Pacific Railroad extends through the southwestern portion of the GRA sub-parallel to highway U.S. 20. In addition, a large network of unimproved roads exist in the GRA. The two WSAs, Hell's Half Acre (33-15) and Cedar Butte (33-4), encompass two of the most recent lava flows within the Snake River Plain and are generally inaccessable due to the rough surface of the young basalt flows.



BLM Wilderness Study Areas Included in the Lava GRA.

WSA	NAME	ACREAGE
33-4	Cedar Butte	35,700
33-15	Hells Half Acre	66,200

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REGION 2 NORTHERN ROCKY MOUNTAINS

Lava GRA, Idaho

Topographic Map

SCALE 1"=4 MILES (1:250,000)
DATA BY WGM | DATE 9/1982 | REVISED
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FIGURE 2

1.3 Basis of the Report

This report is based on compilation, review, and analysis of available published and unpublished data on the geology, energy, and mineral resources of the Lava GRA. The geology of the Lava GRA has been interpreted from aerial photographs by LaPoint (1977) and selected portions have been mapped in detail by Kuntz (1978a), Kuntz et al. (1979), and Karlo (1976, 1977). WGM personnel made a short field visit in October 1982 to the Hell's Half Acre WSA to collect samples of rocks affected by fumarolic activity. The data was compiled and reviewed by WGM project personnel and the Panel of Experts to produce the evaluation which comprises this report. Personnel are as follows:

Greg Fernette, Senior Geologist, WGM Inc.	Project Manager
C.G. Bigelow, President, WGM Inc.	Chairman, Panel of Experts
Joel Stratman, Geologist, WGM Inc.	Project Geologist
Jami Fernette, Land and Environmental Coordinator, WGM Inc.	Claims and Lease Compilation

Panel of Experts

C.G. Bigelow, President, WGM Inc.	Regional geology, metallic and non-metallic minerals, mineral economics.
R.S. Fredericksen, Senior Geologist, WGM Inc.	Regional geology, metallic minerals.
David Blackwell, Ph.D., Professor of Geophysics, Southern Methodist University	Geothermal.
Jason Bressler, Senior Geologist, WGM Inc.	Regional geology, metallic minerals.
Gary Webster, Ph.D., Chairman, Department of Geology, Washington State University	Oil and gas.

William Jones, Senior Geologist, WGM Inc.	Metallic minerals, coal, industrial minerals.
J.F. McOuat, President, Watts, Griffis & McOuat Ltd.	Mineral economics and industrial minerals.
E.F. Evoy, Senior Geologist, Watts, Griffis & McOuat Ltd.	Uranium and thorium.

1.4 Acknowledgements

We would like to thank Tim Carroll, District Geologist, BLM Idaho Falls for allowing us to use his field notes and reports in the compilation of this report.

2.0 GEOLOGY

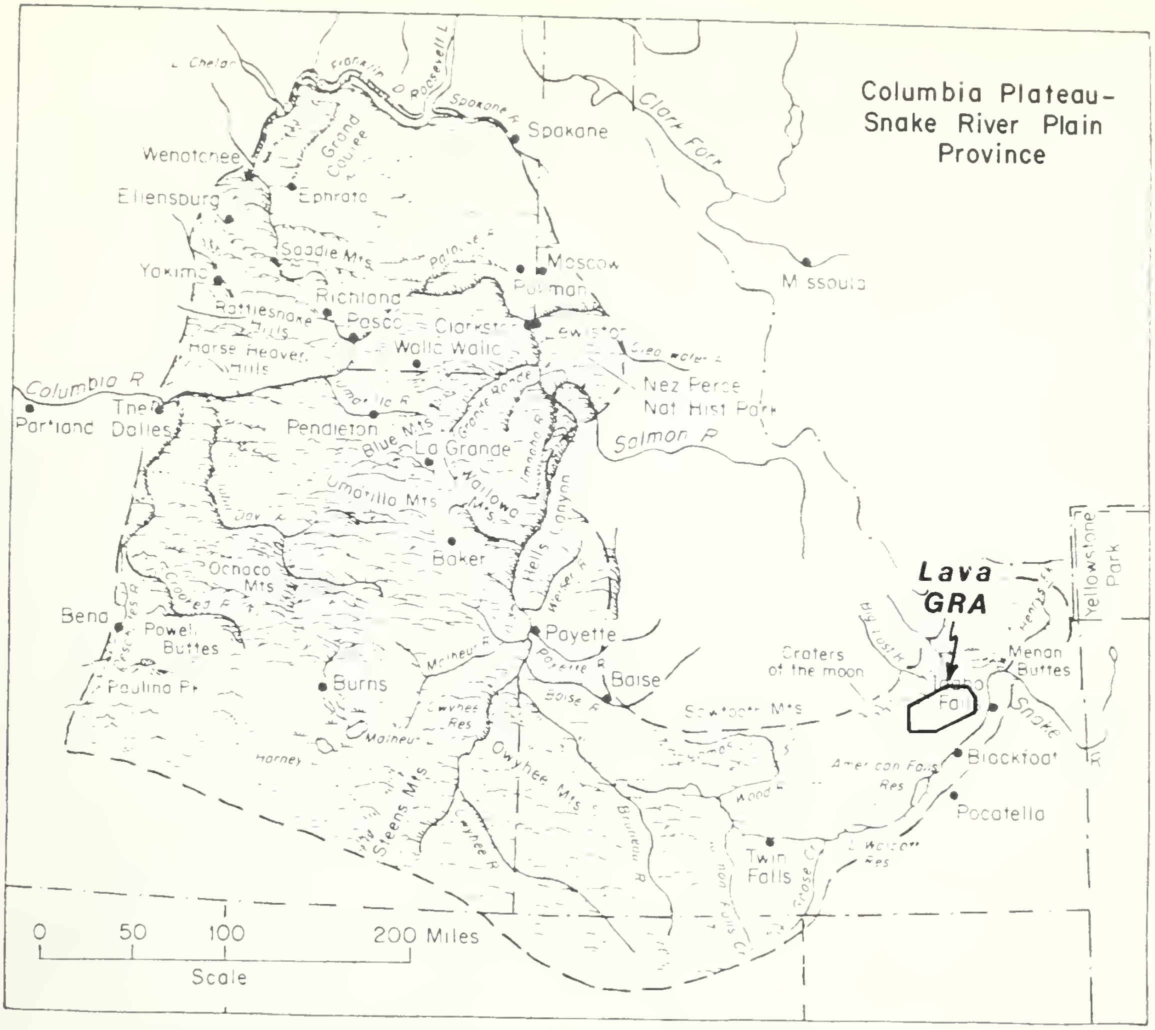
2.1 Introduction

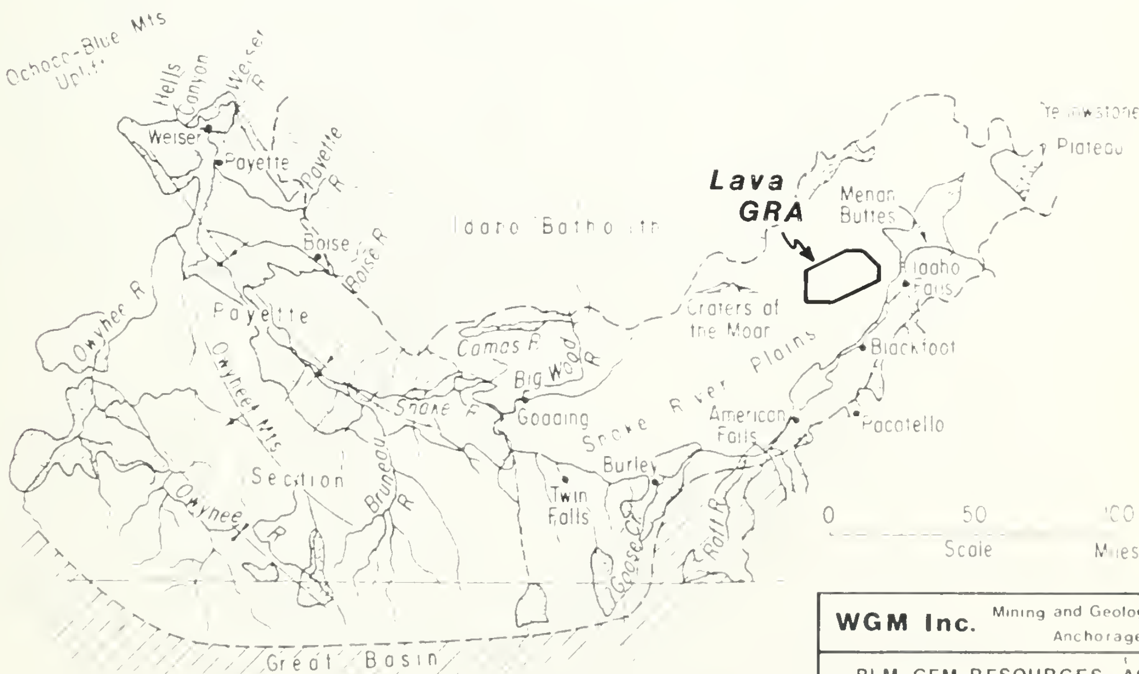
The geology of the Lava GRA has been mapped in part by Kuntz et al. (1979), Kuntz (1978a), as part of a larger mapping program by LaPoint (1977). Various geologic features in the GRA have been studied by Karlo (1977) and Greeley and King (1977).

2.2 Physiography

The Lava GRA is in the Columbia Plateau-Snake River Plain physiographic province (Hunt, 1974). Elevations on the Plain vary between 4,500 and 5,500 feet with a few scattered buttes rising to elevations of over 6,400 feet (Fig. 3). Vegetation consists primarily of bunch grass and tall sagebrush. The amount of vegetation present generally reflects the age of various basalt flows. Recent flows may have virtually no vegetative cover. This high desert climate is marked by hot summers and generally cold winters; annual precipitation is 10 inches or less.

There are no permanent streams within the Lava GRA and all precipitation infiltrates directly into the Snake River Plain Aquifer which is 200-800 feet below the surface.





Cenozoic Lake, Playa, and stream deposits.

Lava

From Hunt (1974).

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Lava GRA, Idaho

Physiographic Setting

SCALE AS SHOWN
DATE 3/1983
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2.3 Description of Rock Units

The bedrock geology underlying the Lava GRA consists of volcanic flows and pyroclastic deposits overlain by colluvium and eolian deposits. Numerous volcanic vents occur in the GRA. Estimated thicknesses of the volcanics range from 9,850 feet to 29,500 feet (Mitchell et al., 1980). The oldest rocks in the Lava GRA are Pliocene (6-2 m.y.) basalt flows. The GRA is underlain predominantly by Pleistocene (2-0.1 m.y.) and Holocene (0.1 m.y. to present) basalts and minor amounts of rhyolite. Typical relationships among the various volcanic units underlying the Snake River Plain are illustrated in Figure 6.

The oldest mapped rock units within the Lava GRA are basalts of Pliocene (6-2 m.y.) age (Fig. 4). These flood basalts occur principally in the central and eastern portion of the GRA (QTb, Fig. 4). Previous workers (LaPoint, 1977) do not provide a description of the unit since the unit has been delineated from photogeologic analysis.

Rhyolitic volcanics (Qrd, Fig. 4) of about the same age or older (0.58±0.9 m.y.) constitute East Butte (sec. 14, T.2N., R.32E.) which consists of silicic volcanic piles surrounded by younger basalt flows. East Butte is a rhyolite dome composed of flows and related breccia of middle to lower Pleistocene age (Kuntz et al., 1979). It is chiefly a buff to purple rhyolitic lava flow with pronounced flow banding and inclusions of basalts. Also present is flow breccia consisting of coarse ash and angular clasts of rhyolite lava and pumice. Similar rhyolites estimated to be 1.42 m.y. old

Lava GRA, Idaho
Explanation for Figure 4

CENOZOIC

Sedimentary

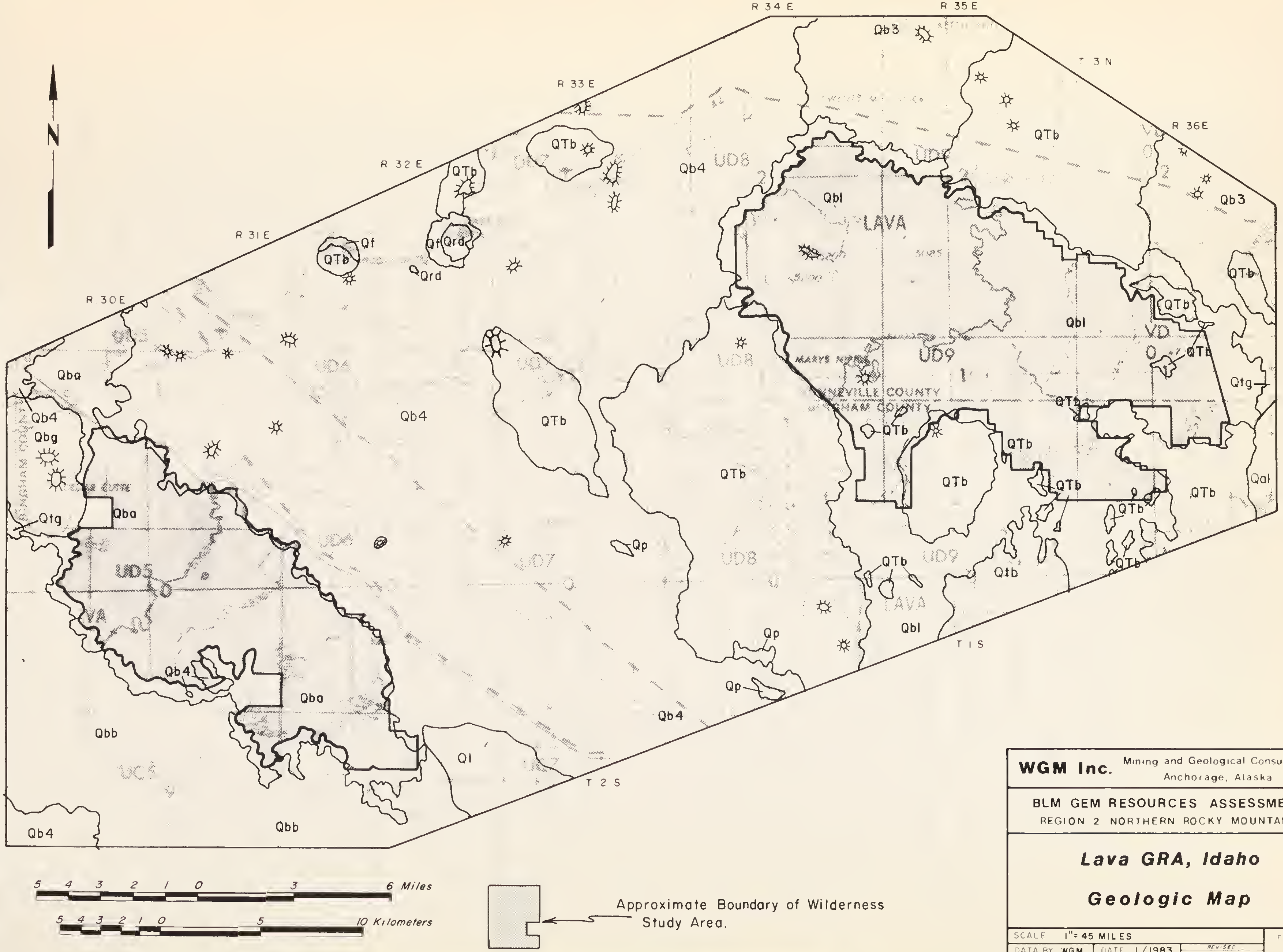
Qal	Stream alluvium
Qp	Playa deposits
Qtg	Terrace deposits
Qf	Alluvial fans
Ql	Loess deposits

Igneous

Qba	Basalt lava flows and pyraclastic deposits	Qb l	Snake River Basalt flows in strati-graphic positian	Recent	Quaternary
Qbb	Basalt lava flows and pyraclastic depasits	Qb3		Pleistocene	Quaternary
		Qb4		Pleistocene	Quaternary
Qrd	Banded rhyalite lava flows and rhyalite flaw breccla			Pleistocene	Quaternary
Qbg	Ferralatlte lava flows and rhyalitic pyraclastic deposits			Pleistocene	Quaternary
QTb	Bosalt			Pliocene	Tertiary

-☼- Volcanic vent

Data by: Kuntz, 1978
Rember and Bennett, 1979
Kuntz, et.al., 1979



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REGION 2 NORTHERN ROCKY MOUNTAINS

Lava GRA, Idaho

Geologic Map

SCALE 1" = 45 MILES			FIGURE
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underlie a small unnamed dome between East and Middle Butte (Kuntz et al., 1979).

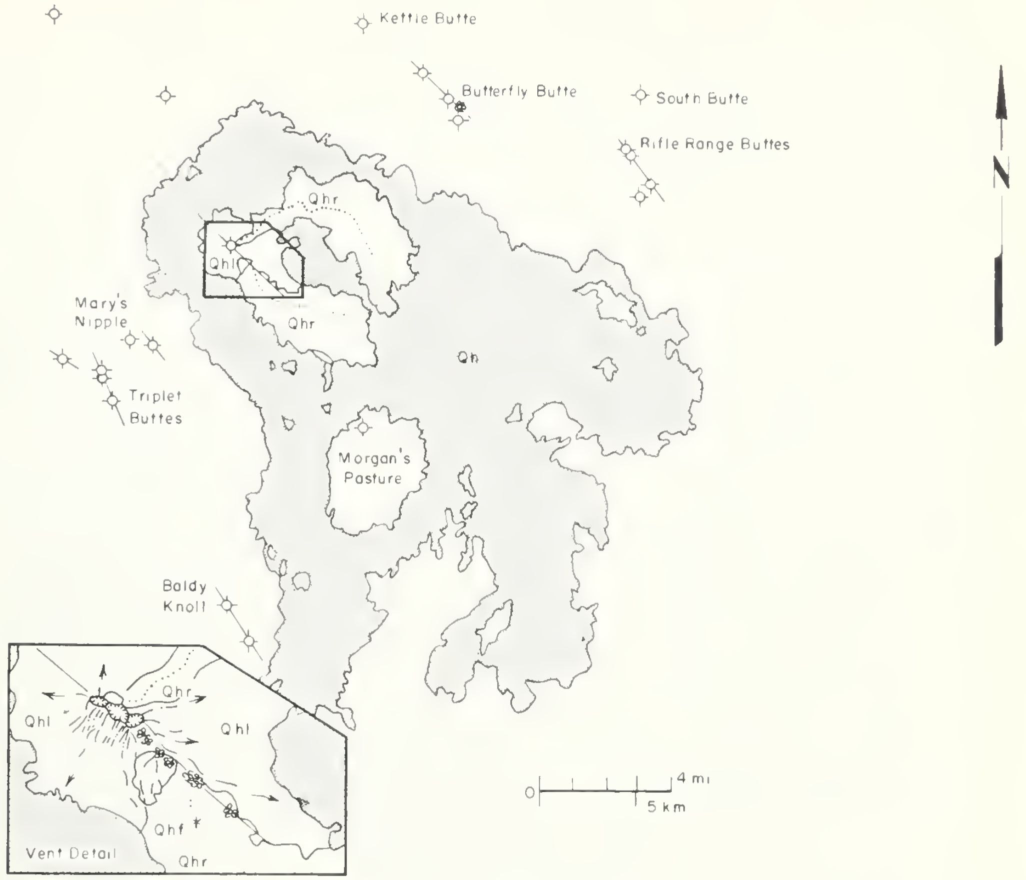
The next youngest map unit (Qbg, (Fig. 4) is ferrolatite found at Cedar Butte, 14 miles southeast of East Butte (T.1N., R.30E.). These buttes are typical of many of the older buttes within the Snake River Plain. They consist of silicic volcanic piles surrounded by younger basalt flows. Qbg is comprised of ferrolatite lava flows and rhyolite pyroclastic deposits of middle Pleistocene age -- estimated to be about 400,000 years old (Kuntz, 1978a, b). The ferrolatite lavas are comprised of light gray ferrolatite with bublous, rough textured flow surfaces. The lavas surround Cedar Butte, a pyroclastic cone, consisting of vent breccia with large (up to several meters) angular blocks of obsidian, pumiceous rhyolite, and minor basalt in a fine-grained red-oxidized, rhyolite matrix (Kuntz, 1978a).

The next youngest basalt unit Qb4 (Fig. 4) floors much of the central portion of the Lava GRA. This unit is delineated from interpretation of aerial photographs and is believed to comprise the oldest flows belonging to the Snake River Group (LaPoint, 1977). The Qb4 map unit is a sequence of flows originating from a number of scattered vents from which issued basaltic lavas ranging in age from 12,000 years old to as much as 700,000 years old. Most are gray to black tube-fed pahoehoe flows and associated pyroclastics erupted from fissure-controlled vents. The unit is locally covered with up to six feet of loess (Kuntz et al., 1979). A succeeding basalt flow unit (Qb3, Fig. 4) occurs predominantly in the eastern portion of the Lava GRA. These flows are similar to basalt units belonging to Qb4 but are interpreted to be somewhat younger from a study of aerial photographs (LaPoint, 1977).

Basalt unit Qbb (Fig. 4) occurs in the southwestern portion of the Lava GRA. This map unit is delineated by field mapping and is comprised of basalt lava flows and pyroclastic deposits estimated to be 12,000 to 100,000 years old (Kuntz et al., 1979). Units Qb4 and Qb3 undoubtedly contain flows equivalent to Qbb. Those flows found within the GRA originated from rift-controlled vents trending north-south through Rock Butte and Rock Corral Butte 12 miles west of the western boundary of the GRA. Flows are dark gray to black, tube-fed pahoehoe basalt lava flows and bedded, moderatly oxidized scoria, cinders and ash (Kuntz et al., 1979).

The next youngest map unit (Qba, Fig. 4) consists of basalt lava flows which were issued from a northwest-trending fracture system and comprise the Cerra Grande lava field. The age has been determined at 10,790±30 (Carbon 14) years (Kuntz, 1978a). The flows are fresh unweathered, gray to black, tube-fed pahoehoe and aa lava flows and bedded, moderately oxidized scoria, cinders, and ash covered with little or no loess (Kuntz, 1978a).

The youngest map unit in the Lava GRA (Qbl, Fig. 4) is made up of flows within Hell's Half Acre lava field. This lava field has been carefully studied by Karlo (1977) who defined several "members" and mapped the vents and fracture system (Fig. 5). It consists of fresh unweathered gray to black, tube-fed pahoehoe and minor amounts of aa lava flows and scoria, cinders, and ash. All flows of this map unit were erupted from an elongate fissure-controlled vent area; two major tube systems carried lava as far as 15.5 miles to the south and southeast of the vent area. At the main vent site (four miles north-northwest of St. Mary's Nipple) are pyroclastic deposits, small cinder cones, and spatter ramparts. An age date on humic



Data from: Karlo, (1977)

MAP SYMBOLS

vents

spatter cones

rootless vents

crater

lava tubes

flow fronts

probable fracture trace

lava channels

Qh — Hell's Half Acre undivided

Qhf — fissure flows

Qhr — rootless vent flows

Qhl — lake overflow

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Lava GRA, Idaho

Geologic Sketch Map of Hell's Half Acre Flow

SCALE AS SHOWN			FIGURE
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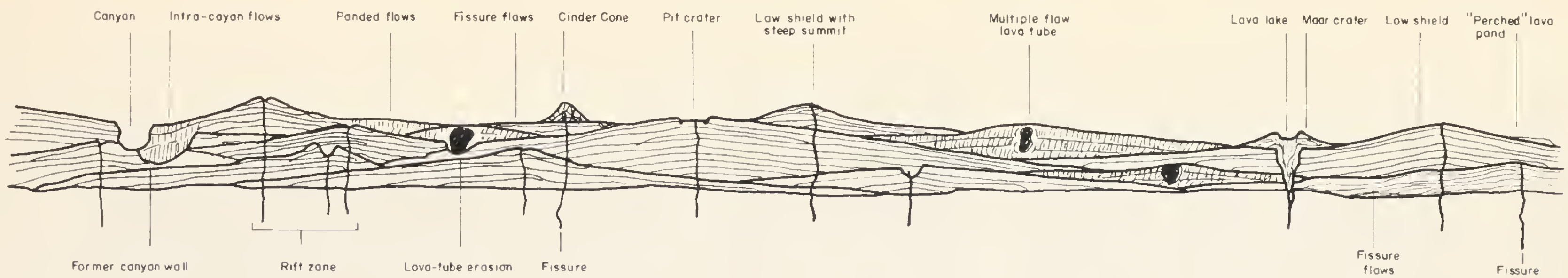
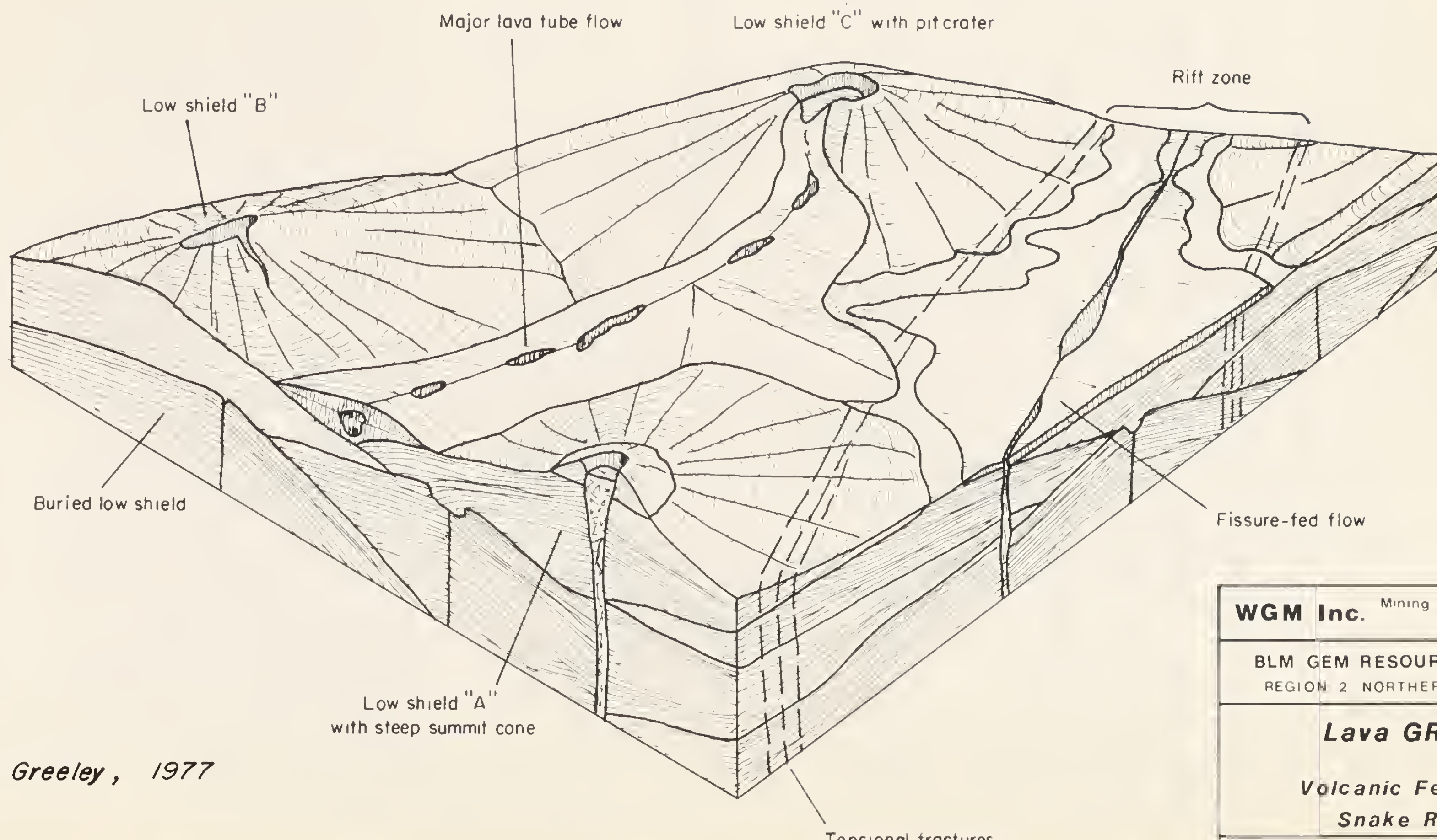
Schematic cross section showing the salient features of a 'plains' basalt region, typified by the central Snake River Plain.



Block diagram showing relationship of low shields, major lava tube flows, and fissure flows.



Source: Greeley, 1977

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BLM GEM RESOURCES ASSESSMENT REGION 2 NORTHERN ROCKY MOUNTAINS	
Lava GRA, Idaho *Volcanic Features of the Snake River Plain*	
SCALE	FIGURE 6
DATA BY NGM · DATE 3/1983 · REVISED	
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soil obtained beneath the flow yields a Carbon 14 age date of 4,100 ±200 years (Kuntz et al., 1979).

Karlo (1977) notes that a minor late phase of vent activity at the Hell's Half Acre was fumarolic. Various sulfates were deposited as crusts along fractures and in cavities between flow units. Identified mineral species are gypsum, bloedite ($MgSO_4Na_2SO_4.H_2O$) and thenardite (Na_2SO_4). Apparently the timing of sulfate deposition is unclear, but the sulfates occur within lava flows and are truncated by lake-collapse scarps; thus, they may be partly synchronous with lake activity.

Surficial playa, lacustrine, loess, terrace and alluvial fan deposits occur at several locales in the Lava GRA (Fig. 4).

2.4 Structural Geology and Tectonics

The crustal structure of the eastern Snake River Plain (ESRP) has been recently studied by Braile et al. (1982) and summarized as follows:

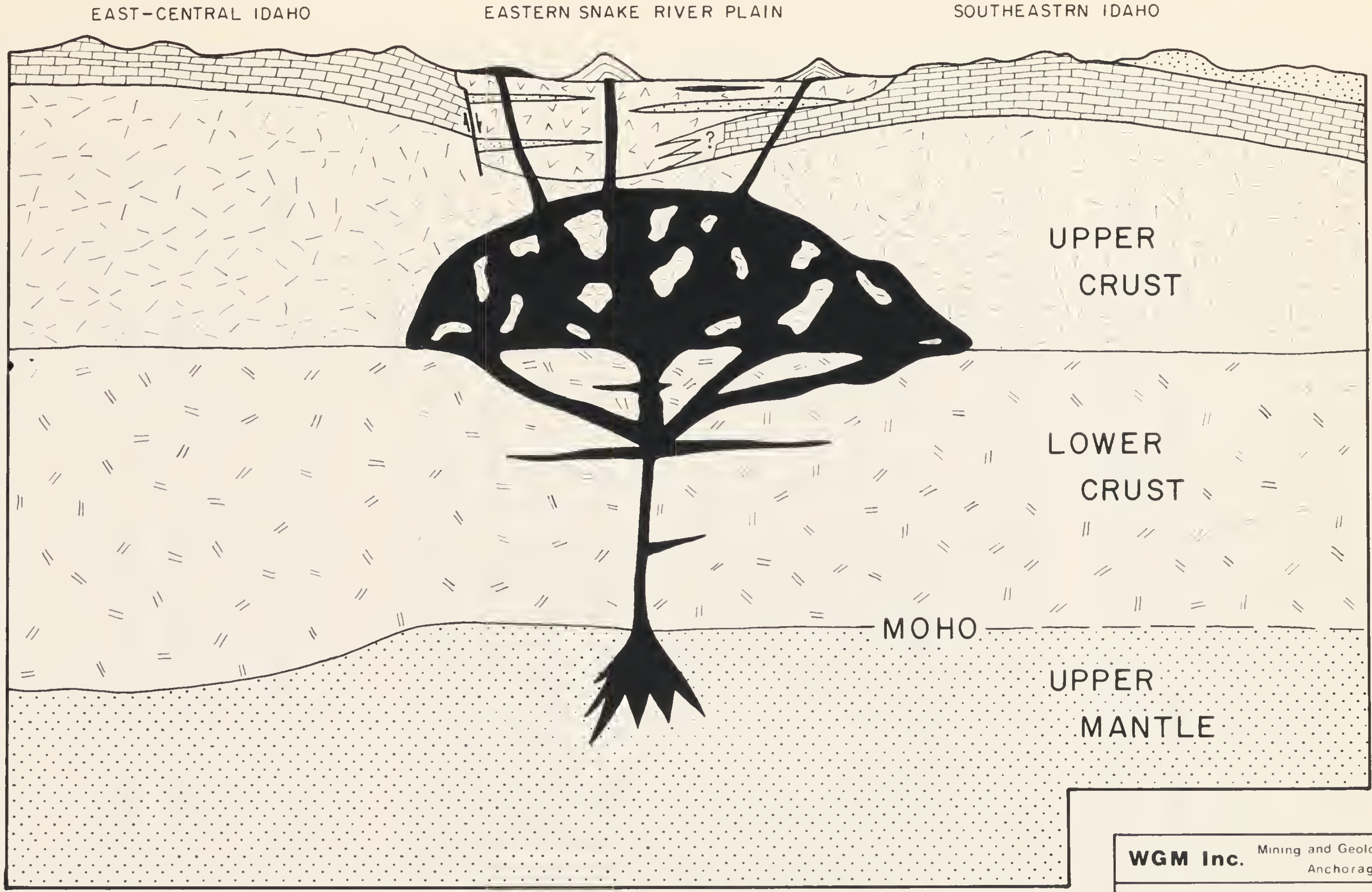
> Previous geological and geophysical studies of the ESRP indicate that it is a volcanic-filled depression which trends nearly perpendicular to the regional structures of the Basin and Range, Northern Rocky Mountains, and Middle Rocky Mountains provinces which bound the ESRP. To the northeast of the ESRP are the Island Park and Yellowstone Calderas which have displayed volcanic, seismic, and hydrothermal activity within the last million years. Kirkham (1931) suggested that the ESRP is a simple downwarp and that faulting along the margins of the plain has been of minor importance. However, Sparlin et al. (1982) have demonstrated the existence of major faulting along the northwestern boundary of the ESRP from seismic and gravity modelling. Gravity studies (Hill, 1963: Mabey, 1976, 1978; LeFehr and Pakiser, 1962) have

identified a prominent positive gravity anomaly which approximately coincides with the axis of the ESRP, but is more localized toward the northern part of the downwarp in the western Snake River Plain. Deep crustal structure information from seismic data is asbent in the ESRP, but a seismic refraction profile from Mountain City to Boise in the western Snake River Plain (Hill and Pakiser, 1966; Prodehl, 1979) has demonstrated that the western Snake River Plain consists of a thick, high-velocity (6.7 km/s) crust with a surface layer of lower-velocity volcanic materials. To the south of the ESRP, the northeastern Basin and Range province is characterized by lower, average crustal-velocity (6.3 km/s) and a crustal thickness of about 30 km (Braile et al., 1974; Keller et al., 1975; Smith, 1977, 1978; Hill and Pakiser, 1966). Armstrong et al. (1975) utilized K-Ar dates of late Cenozoic silicic volcanic rocks of the ESRP to demonstrate a systematic age progression of volcanism along the ESRP. Their date indicate the silicic volcanic activity began about 15 m.y. ago in southwestern Idaho and progressed at an average rate of approximately 3.5 cm/yr. northeastward toward its present site at the Yellowstone plateau. They also indicate that the initiation of basaltic volcanism has followed this same time progression, with a lag of approximately 2 to 5 m.y. after the silicic volcanism. In addition, the basaltic volcanism in the southwestern portion of the ESRP has remained active sporadically to the present. Today, the Yellowstone Caldera is representative of this silicic phase of volcanism which characterizes the volcanic progression, and the Island Park region represents the leading edge of the basaltic volcanic activity. Brott et al. (1978) utilized heat flow data on the western Snake River Plain and an observed heat flow-elevation relationship for the western and eastern Snake River Plain to propose a tectonic model for the development of the Y-SRP (Yellowstone-Snake River Plain) volcanic province. According to their model, the time progression of volcanism along the eastern Snake River Plain is accompanied by intrusion into the crust and rapid transfer of heat to the surface by intrusion and eruptions. High heat-flow adjacent to the margins of the ESRP is observed, but low values are observed in the ESRP itself due to ground water circulation in the Snake River Plain aquifer (Brott et al., 1978). According to the model suggested by Brott et al., cooling of the crust after the intense silicic volcanic activity results in the subsidence which is presently observed as the eastern Snake River Plain downwarp.

Several additional tectonic models have been proposed to describe the geologic evolution of the eastern Snake River Plain during the past 15 m.y. Hamilton and Myers (1966) suggested that the ESRP consists of a tensional rift. Morgan (1972) and Smith and Sbar (1974) described the eastern Snake River Plain-Yellowstone system as the track of a mantle plume or hotspot. Finally, Taubeneck (1971) suggested that the ESRP was laterally faulted and the upper crust pervasively intruded by dikes.

A schematic diagram illustrating the crustal structure of the eastern Snake River Plain is shown in Figure 7. Braile et al. (1982, p. 2607) have suggested a tectonic model which seeks to provide a reasonable qualitative explanation for the observable crustal structure (based on seismic profiles), thermal anomalies, and volcanic history during evolution of the Yellowstone-Snake River Plain system. Their model is as follows:

> When these observations are considered in conjunction with the volcanic age progression relationships described by Armstrong et al. (1975) and the thermal model proposed by Brott et al. (1978) for the evolution of the eastern Snake River Plain, a possible evolutionary model of the crust during the past 15 m.y. is suggested. Initially, a thermal perturbation of the crust results in 3 to 4 km of surface uplift, intense silicic volcanism, and subsequent caldera collapse. During this stage, basaltic magma from the upper mantle rises rapidly through the lower crust, producing only minor velocity structure perturbations. As the hot magma contacts the sialic upper crust, it causes partial melting of a part of the upper-crustal layer (as evidenced by the low velocity upper-crust beneath the Yellowstone area) during the process of rapid transfer of volcanic material and heat to the surface. Partial melting of these upper crustal rocks generates the silicic volcanism. This phase is presently represented by the Yellowstone plateau. As the 'hotspot' moves to the northeast, cooling of the intruded upper crust generates the high-density, high-velocity intermediate layer in the ESRP and results in rapid subsistence of the crust.
>
> Continued cooling, subsidence due to thermal contraction, and minor, periodic basaltic volcanic activity persists through the remainder of the at least 15 m.y. evolutionary sequence. Due to the depletion of silicic material in the crust, this late-stage volcanism is of lesser intensity and probably represents rapid ascent of magma through small dikes or pipes from the upper mantle. An example of these late-stage volcanics is found in the Craters of the Moon, Idaho, area. Considering the potential geothermal anomalies along the Y-SRP system, the recent basaltic volcanism would represent a minor thermal anomaly in the crust. However, partial melt zones in the upper crust associated with silicic volcanism could produce significant temperature anomalies but would be restricted to the Yellowstone plateau and extreme northeastern part of the ESRP. Additional geothermal anomalies could be present near the axis of the ESRP due to shallow (7 to 10 km) intrusion of high-density and high-velocity rocks of the intermediate layer, or along the northwestern margin of the ESRP where a fault of at least 4 km offset could provide a route for upward migration of hot fluid.
>
> Although much remains to be learned about the geology and tectonics of the Yellowstone-Snake River Plain area, the model described above provides a reasonable, qualitative explanation for the observed crustal structure, thermal anomalies, and volcanic history during crustal evolution of the Yellowstone-Snake River Plain system.



From: *Sparlin, et. al. (1982).*

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Lava GRA, Idaho

Schematic Diagram of Crustal Structure Eastern Snake River Plain

SCALE			FIGURE
DATA BY	DATE 3/1983	REVISED	7
DRWN BY DSI	APRVD G F		

Karlo (1977) points out that although most discussion of Snake River Plain volcanism revolves around features exhibited by the Craters of the Moon volcanic field, the Snake River Plain shows a diversity of "rift zones" and associated lava fields. The Hell's Half Acre system is another such field and, although dissimilar from the Craters of the Moon system, is probably more typical of most of the constructs which constitute the Plain.

Fractures associated with the Hell's Half Acre field are parallel to the regional tectonic grain. Such fractures control many of the vent features on the Plain and where documented the predominant orientation, as at Hell's Half Acre, is northwesterly. Karlo (1977) notes that these fractures appear to be the primary tectonic features of the province and suggest that the direction of maximum tension is along the axis of the Plain rather than across the Plain as is commonly believed.

Less is known about the structural setting of the Cerro Grande lava field. However, the elongation of the field in a northwest-southeast direction, and the presence of similarly aligned fractures on trend with the field (LaPoint, 1977; Kuntz, 1978) indicate an overall setting similar to that of the Hell's Half Acre field.

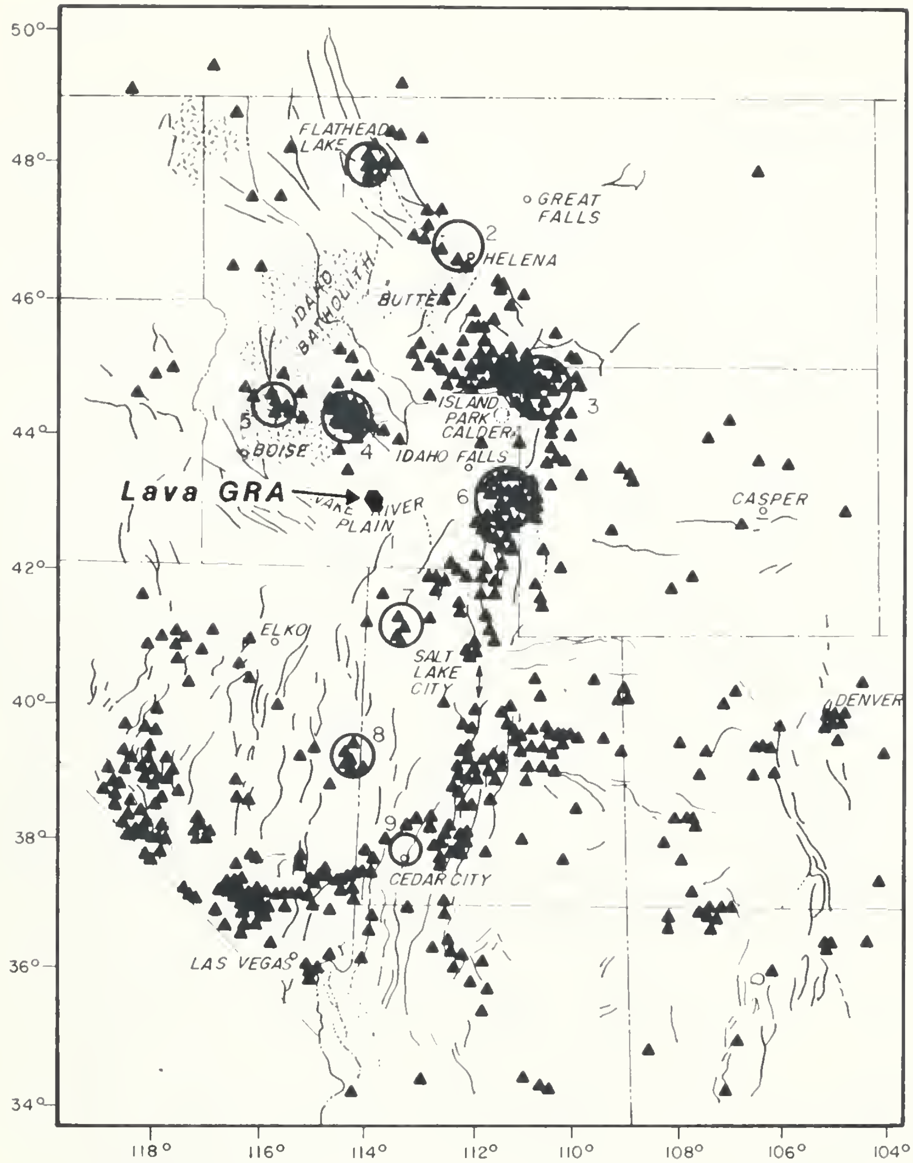
Geologic hazards in the Lava GRA are related essentially to the prospects of recurrent volcanism. The relative youth of lava fields such as the Hell's Half Acre and Cerro Grande field indicate that volcanic activity could resume at any future time. Luckily the nature of late-stage basaltic volcanism on the Plain is not of an explosive character. Principal damage would be confined to destruction of road systems and man built structures. These types of eruptions are seldom associated with severe seismic activity. In general, the Snake River Plain is aseismic with respect to the surrounding provinces to the north, south and east (Fig. 8). The potential hazards are somewhat greater to the north where stored radioactive wastes at the Idaho National Engineering Laboratory could be disrupted (Kuntz, 1978).

2.5 Paleontology

There are very few geologic units within the Lava GRA which are favorable for the accumulation and preservation of fossils. Fossil remains of small vertebrates could occur in the scattered playas within the GRA. Such fossil locales are present in the Hagerman Lake beds to the southeast. Additionally, small collapse structures within basalt flows sometimes create predator traps in which rich fossil finds can accumulate; these result when predators in search of prey enter these steep sided natural traps and cannot escape. These features elsewhere on the Plain have resulted in preservation of unique vertebrate fossils exhibiting a wide diversity of species.

2.6 Historical Geology

The general overview of the geologic evolution of the Eastern Snake River Plain (ESRP), as proposed by Braile et al. (1982, p. 2607), is summarized in Section 2.4. In the Lava GRA, the oldest rocks are various flood basalts belonging to the QTb group (Fig. 4). Within the GRA, as elsewhere on the ESRP, some of the earliest volcanics are acidic in composition. These volcanics, although largely buried by later basalt flows, underlie some of



EPICENTERS FOR INTERMOUNTAIN SIESMIC BELT SHOWING ALL EARTHQUAKES REPORTED BY NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) OF ABOUT MAGNITUDE 3.0 OR GREATER FROM 1961 THROUGH 1970. DOUBLE ARROW SHOWS ZONE OF LOW SIESMICITY. CIRCLES MARK EARTHQUAKE SWARMS: 1, FLATHEAD LAKE, MONT.; 2, HELENA, MONT. 3, YELLOWSTONE PARK; 4, SAWTOOTH RANGE, IDAHO; 5, IDAHO BATHOLITH; 6, CARIBOU RANGE, IDAHO 7, GREAT SALT LAKE DESERT, UTAH 8, LEHMAN CAVE MONUMENT, NEVADA 9, CEDAR CITY, UTAH

DATA FROM SMITH AND SBAR (1974)

0 70 140 210 MILES
SCALE APPROXIMATE

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Lava GRA, Idaho

Regional Seismicity

SCALE			FIGURE
DATA BY	DATE 9-83		**8**
DRWN BY TSM	APRVD		

the older buttes, such as Cedar Butte and East Butte. The silicic volcanics represent early stages of volcanism and reflect partial melting and involvement of the sialic crust. As volcanism continued deeper sources of magma were tapped and the magmatic source evolved to basaltic in character. This is reflected by the composition of late Pleistocene and Holocene flows.

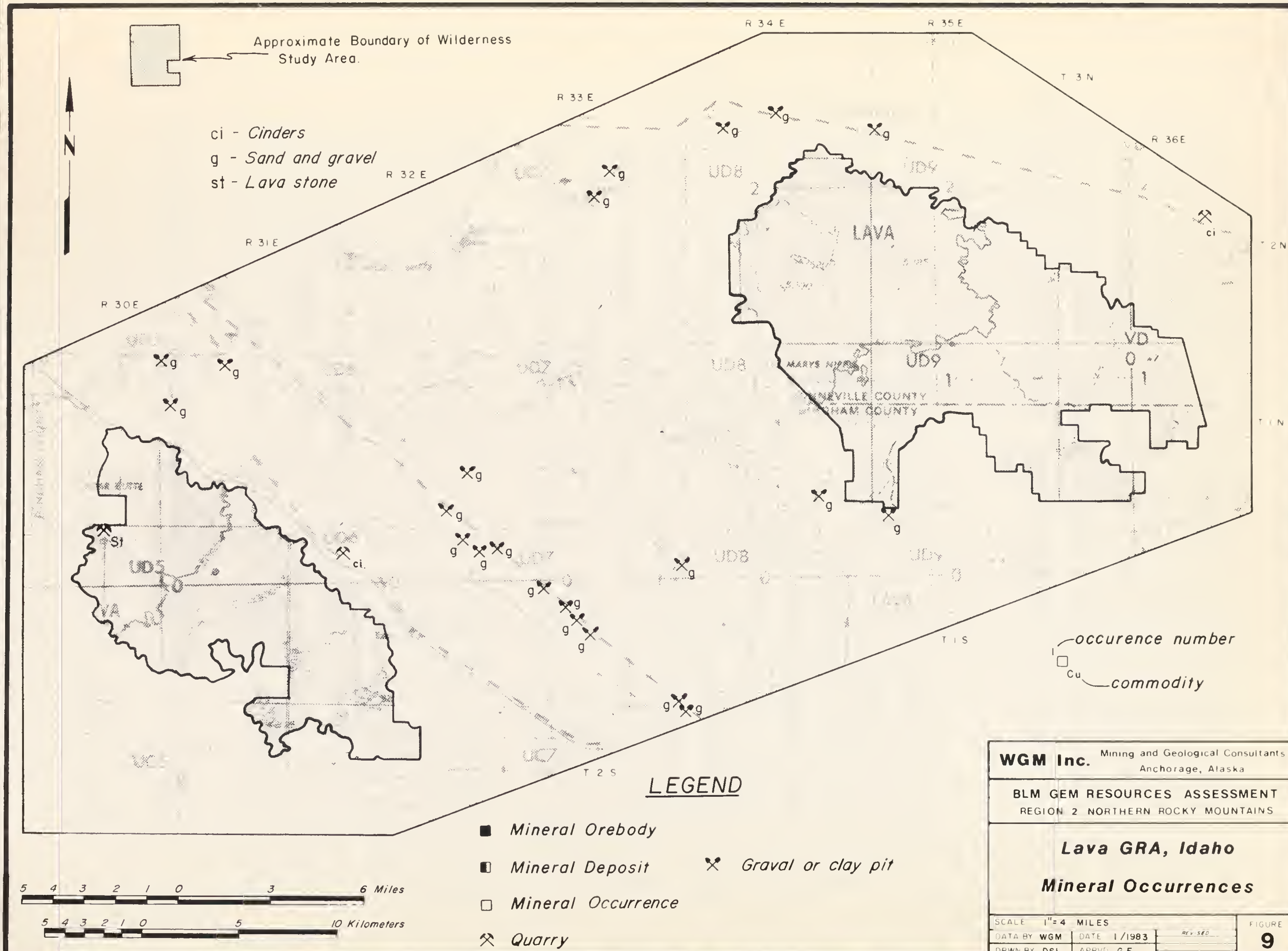
3.0 ENERGY AND MINERAL RESOURCES

No specific studies have been conducted in the Lava GRA for metallic mineral resources. A study of geologic terrane, west of the Lava GRA, in the proposed Great Rift Wilderness Area determined the resource potential to be confined to decorative stone, consisting of filamented pahoehoe, and cinders (Kuntz et al., 1980). Rember and Bennett (1979) have conducted a compilation of mineral occurrences of the Idaho Falls Quadrangle; this compilation does not show any metallic or non-metallic occurrences, but a number of sand and gravel and cinder occurrences are shown. Carroll (1980), has conducted studies of certain types of building stones found within the GRA.

3.1 Known Mineral and Energy Deposits

The compilation of Rember and Bennett (1979) shows the presence of 22 sand and gravel pits, 2 cinder localities, and 1 quarry site in the Lava GRA (Fig. 9). Sand and gravel resources have been exploited from intermittent stream beds along U.S. Highways 26 and 20. Cinders and pumice have been exploited at a site in the extreme eastern portion of the GRA, Cinder Hill (Asher, 1965), and pumice has been produced at a site along U.S. Highway 26 known as No. 49 Pit (Strowd et al., 1981).

Slab basalt has been mined from several localities in the Lava GRA, principally from amenable material at the Hell's Half Acre lava field (Fig. 9). Mineable material consists of pahoehoe slabs in poligonal plates 1 to 4 inches or more thick and several inches to a few feet across (Carroll,



Approximate Boundary of Wilderness Study Area.
N
ci - Cinders
g - Sand and gravel
st - Lava stone
R 30E
R 31E
R 32E
R 33E
R 34E
R 35E
R 36E
T 3N
T 2N
T 1N
T 1S
T 2S
LAVA
BONNEVILLE COUNTY
BINGHAM COUNTY
occurence number
Cu
commodity
LEGEND
Mineral Orebody
Mineral Deposit
Mineral Occurrence
Quarry
Graval or clay pit
5 4 3 2 1 0 3 6 Miles
5 4 3 2 1 0 5 10 Kilometers
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REGION 2 NORTHERN ROCKY MOUNTAINS
Lava GRA, Idaho
Mineral Occurrences
SCALE 1"=4 MILES
DATA BY WGM
DATE 1/1983
DRWN BY DSI
APRVD G.F.
FIGURE 9

1980). This decorative stone is marketed in several western states. Carroll (1982) reports that an estimated 6,000 tons of lava rock have been sold from common use and commercial sale areas south of the Hell's Half Acre WSA; over the decades unauthorized removal from the lava field of up to 1,000 tons has been reported. Slab lava production and reserve data is shown in Table I.

In an attempt to inventory slab pahoehoe lava rock resouces of the Hell's Half Acre field, Carroll (1980) examined 22 four-acre plots comprising one percent of the area of the lava field. Marketable lava slabs were counted within each plot and reserves were estimated using assumptions based on past and present removal operations. The marketable pieces were assumed to be less than 3 to 4 inches thick with at least one dimension greater than seven inches; the slabs were also assumed to average 100 pieces per ton. The results of the study indicate that 7,873 tons of reserves are present on the 8,715 acres of the general use area (Carroll, 1980). By analogy the entire lava field contains 70,000 tons of marketable slab lava (Carroll, 1982).

Within the Cedar Butte WSA, Carroll (1982) reports that public sales of lava rock made from March 1977 to March 1980 from community pit I-13075 (Lot 1, NE 1/4 , SE 1/4, section 1, T.1S., R.30E.; Fig. 12) total 100 to 300 tons. In the Cedar Butte WSA, Carroll (1982) conducted an inventory similar to that at the Hell's Half Acre WSA in July 1980 and July 1981. He estimates that 15,000 tons of marketable slab lava occur within the Cedar Butte WSA.

No hydrocarbon or geothermal deposits are known within the Lava GRA.

TABLE I

SLAB LAVA ROCK MARKET DATA FROM MAJOR STONE DEALERS IN IDAHO FALLS, IDAHO[1]

Dealer	Source/Supplier	Cost Per Ton		Sales	
		Wholesale	Retail	Tons (ea.)	Tons
BLM	Public Snake River Basalt Flows	$ 4.25 pit-run		1-50[1]	500-600
Messinger Brick & Masonry Supply	Firth, ID, Wholesaler	45.00	$80.00	2	2
Rocky Mountain Supply	Neilson, Idaho Falls Parsona, Blackfoot Kemock, Firth(?) (published private sources)	45.00	90.00	25[2]	250

(1) Source: Carroll (1980).
(2) Also four sales from 120 to 2,000 tons each.
(3) Phasing out slab lava dealing. Last deliveries made in 1978 and 1979.

3.2 Known Mineral and Energy Prospects, Occurrences and Mineralized Areas

There are no known mineral or energy prospects, occurrences or mineralized areas in the Lava GRA. Karlo (1977) reported the occurrence of fumarolic activity at vent areas in the Hell's Half Acre field. WGM personnel visited the site and collected two samples for geochemical analysis (Fig. 10; Table II). Neither of the samples shows any enrichment of gold, arsenic, antimony or mercury.

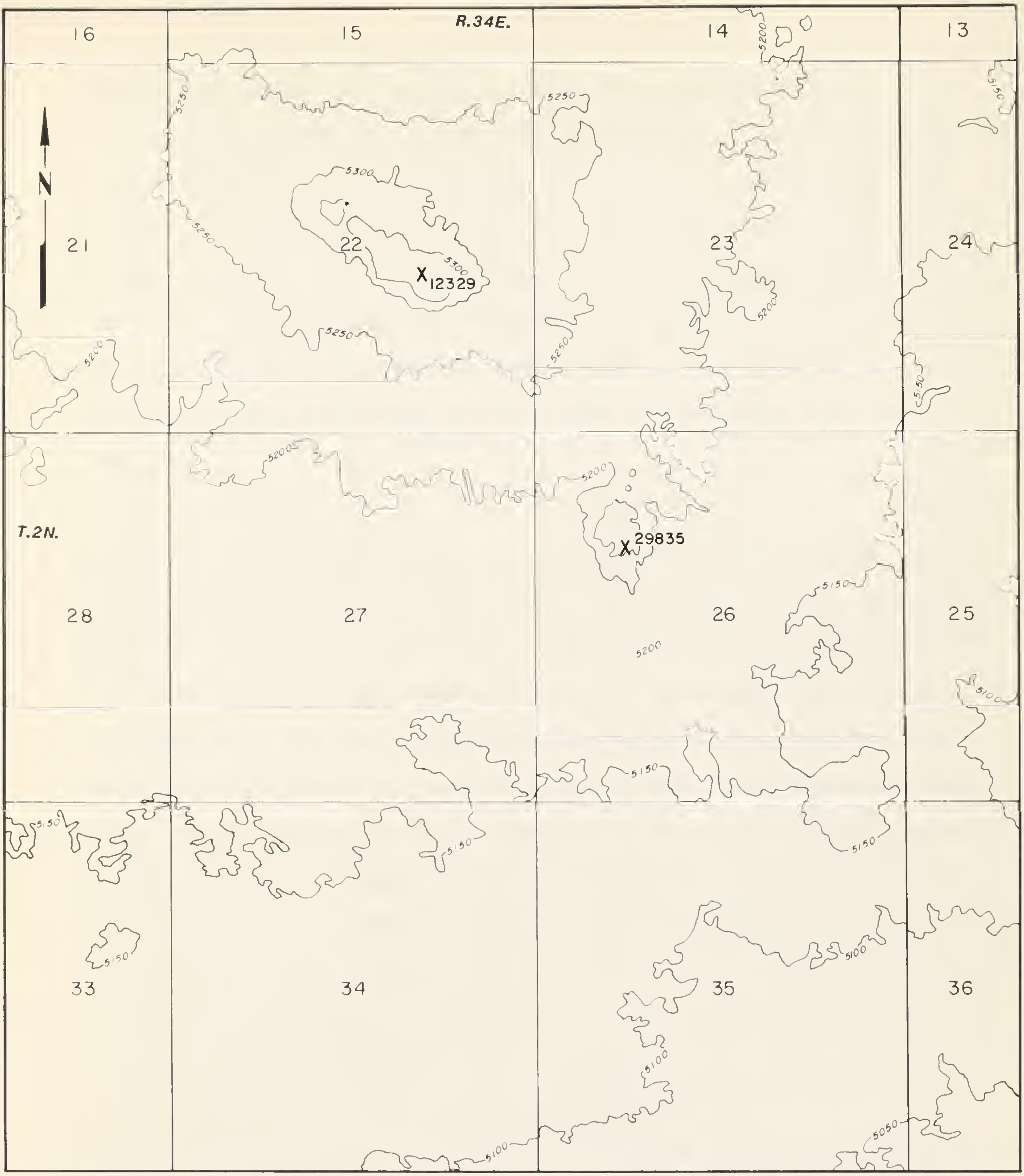
TABLE II

GEOCHEMICAL RESULTS OF ROCK SAMPLING-

HELL'S HALF ACRE VENT SITE

Sample No.	Description	Au (ppm)	As (ppm)	Sb (ppm)	Hg (ppm)
12329	White sulfate from fracture near fumarolic vent within main vent area of Hell's Half Acre	.02	10	2	.02
29835	White sulfate from within base of large lava bubble	.02	10	5	.01

There are no thermal manifestations within the Lava GRA. In fact there are no perennial streams within the GRA and all precipitation infiltrates directly to the Snake Plain Aquifer, a huge regional aquifer 200-800 feet below the surface in the Quaternary basalts of the Eastern Snake River Plain (Mundorff et al., 1964). The aquifer has been extensively studied in this area and in the adjacent Idaho National Engineering Laboratory (INEL) site (Crosthwaite, 1973; Barraclough et al., 1966). There is extensive development of the aquifer for irrigation use and for use at the INEL site



5 4 3 2 1 0 5 MILE

Legend

X 29835 Rock sample site and number.

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REGION 2 NORTHERN ROCKY MOUNTAINS

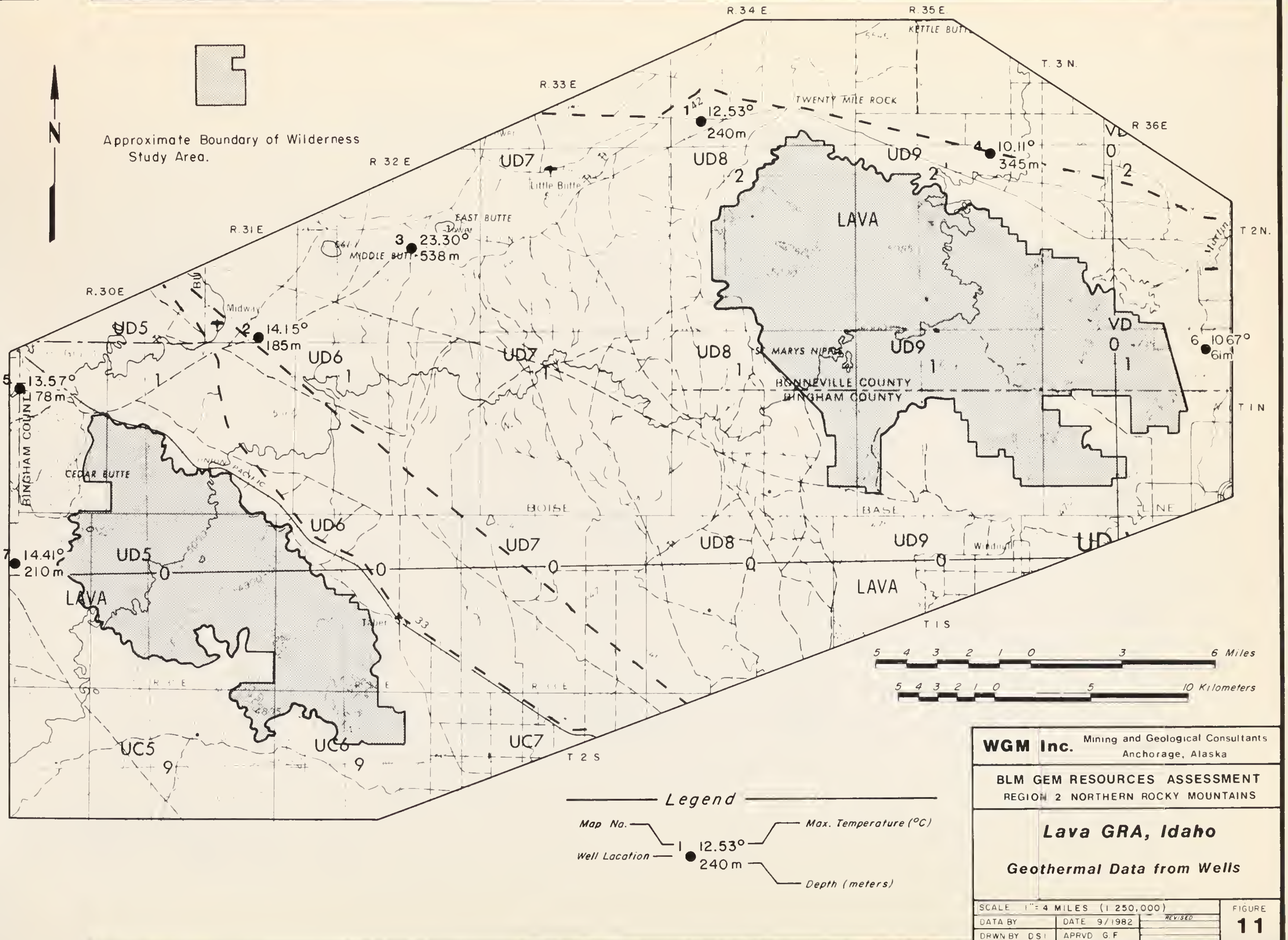
Lava GRA, Idaho

Rock Samples Collected for Geochemical Analysis Hell's Half Acre Vent Site

SCALE 1"=2000' (1:24,000)			FIGURE
DATA BY WGM	DATE 3/1983	REVISED	10
DRWN BY DSI	APRVD G F		

immediately northwest of the GRA. Consequently, extensive geologic information is available on the shallow basalt section. However, below the Quaternary basalts, little information is available. The basalts are greater than 1,130 feet thick in sec. 2, T.2N., R.35E. (loc. 4, Fig. 11). In sec. 1, T.3N., R.29E., the basalts (with some interbedded sediments) extend to a depth of 2,170 feet (Doherty et al., 1979). A core hole in sec. 22, T.2N., R.32E., midway between Middle Butte and East Butte was in Quaternary basalt and silicic intrusive rocks for its entire 1,765 foot length.

Brott et al. (1981) report geothermal data from wells in the Eastern Snake River Plain, including seven holes within the Lava GRA (Fig. 11; Table III), but none of the holes are in the WSAs. The holes range in depth from 200 to 1,765 feet and typical heat gradients in the holes are very low (30°C/km, 1.6°F/100 ft.). The heat low gradients are due to the fact that the water moves very fast through the Snake Plain Aquifer and removes the earth's heat flow. Typical temperatures in the aquifer are not much above, and may even be below the surface temperature, because much of the infilterating water comes from snow melt originating in the mountains surrounding the Snake River Plains. Typical temperatures in the aquifer in the GRA range from 10°C along the eastern side (influenced by infiltration from the Snake River) to 12-14°C along the northwest side where the influence of the infiltration is less either because of permeability differences or because it is farther from zones of infiltration. The highest temperature measured in the area is from a hole located between Middle Butte and East Butte (loc. 3, Fig. 11) where the aquifer temperature is 19.4°C and the bottom hole temperature is 23.3°C. The geothermal gradient in the bottom of the hole,



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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Lava GRA, Idaho

Geothermal Data from Wells

SCALE 1" = 4 MILES (1 250,000)			FIGURE
DATA BY	DATE 9/1982	REVISED	11
DRWN BY DSI	APRVD G F		

TABLE III

GEOTHERMAL DATA FROM WELLS IN OR NEAR THE LAVA GRA, IDAHO[2]

(Brott et al., 1981)

Map Location[1]	Collar Elevation (m)	Depth Interval (m)	Geothermal Gradient (°C/km)	Heat Flow (10^{-6} cal/cm^{2}sec)	Maximum or Bottom Hole Temp (°C)	Relation to Snake Plain Aquifer
sec. 1, T.3N., R.29E. Not shown	1,561	88- 230	15.5±0.4	0.53	14.55	IN
		230-3100	41.5±2.0	2.61	150	BELOW
1	1,590	20- 220	17.6±0.2	0.59		ABOVE
		220- 240	---		12.53	IN
2	1,531	20- 185	29.5±0.4	1.05	14.15	ABOVE
3	1,637	20- 300	31.7±4.3	1.78		ABOVE
		300- 455	5.3	0.25	19.5	IN
		455- 538	41.7±1.0	1.57	23.30	BELOW
4	1,551	200- 345	0.1±0.2	0.01	10.11	IN
5	1,518	10- 179	20.5	0.72	13.57	ABOVE
6	1,424	10- 61	-8.9±9.8	-0.30	10.67	ABOVE
7	1,564	30- 120	34.8±1.0	1.22		ABOVE
		120- 210	10.9±0.9	0.36	14.41	IN

(1) Refer to Figure 11.
(2) Source: Brott et al., 1981.

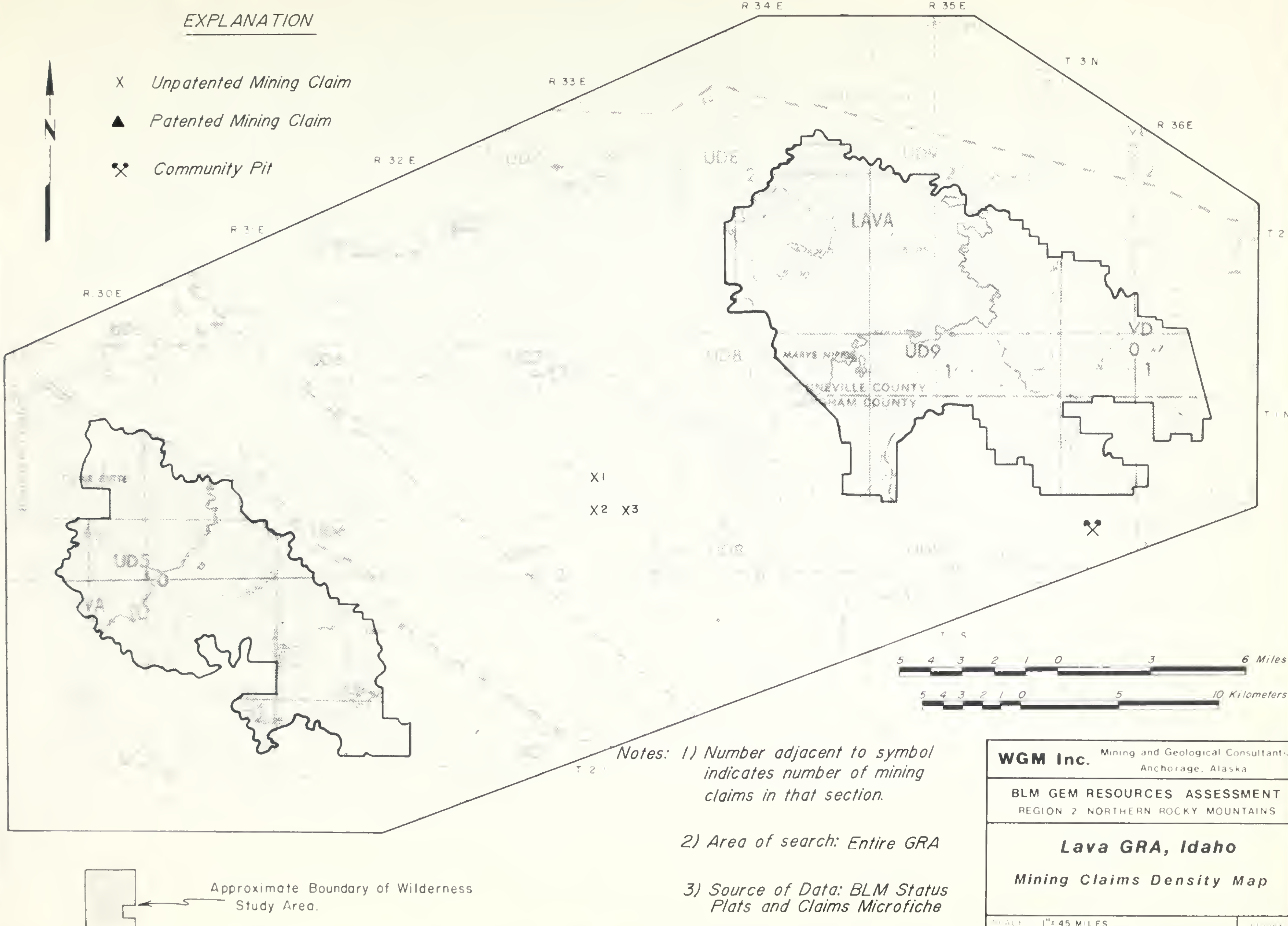
possibly below the aquifer is 42°C/km (2.3°F/100 ft.). The deepest drill hole in the Eastern Snake River Plains, the INEL test well, was drilled to a depth of 10,365 feet and had a bottom hole temperature of 150°C (Doherty et al., 1979). The hole was in basalt with minor interbedded sediment to a depth of 2,150 feet and in late Cenozoic rhyolitic and rhyodacite rocks from 2,450 feet to total depth. No significant aquifers were located in the silicic section.

Extensive chemical data are available for the waters of the Snake Plain Aquifer beneath the INEL site and to a lesser extent for much of the Eastern Snake River Plain. A contour map of the flouride concentrations in ground water (Barraclough et al., 1966) shows a plume of higher flouride concentrations in the center of the Eastern Snake River Plain. Presumably this pattern is due to the dilutive effect caused by the recharge of very fresh water along the margins of the aquifer. Silica values are generally low in aquifer and no anomalous geochemistry has been noted that might indicate areas where geothermal leakage from greater depths is occurring.

No hydrocarbon exploration test wells have been drilled in the Lava GRA. The nearest tests to the GRA were drilled approximately 15 to 33 miles to the southeast and were dry holes (Breckenridge, 1982).

3.3 Mining Claims, Leases and Material Sites

A review of BLM claim records current to June 7, 1982 shows six unpatented mining claims within the Lava GRA (Fig. 12). Oil and gas lease plats for the GRA were reviewed and are current to August 12, 1982. Approximately one



Notes: 1) Number adjacent to symbol indicates number of mining claims in that section.

2) Area of search: Entire GRA

3) Source of Data: BLM Status Plats and Claims Microfiche

4) Data current to: June 7, 1982

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Lava GRA, Idaho

Mining Claims Density Map

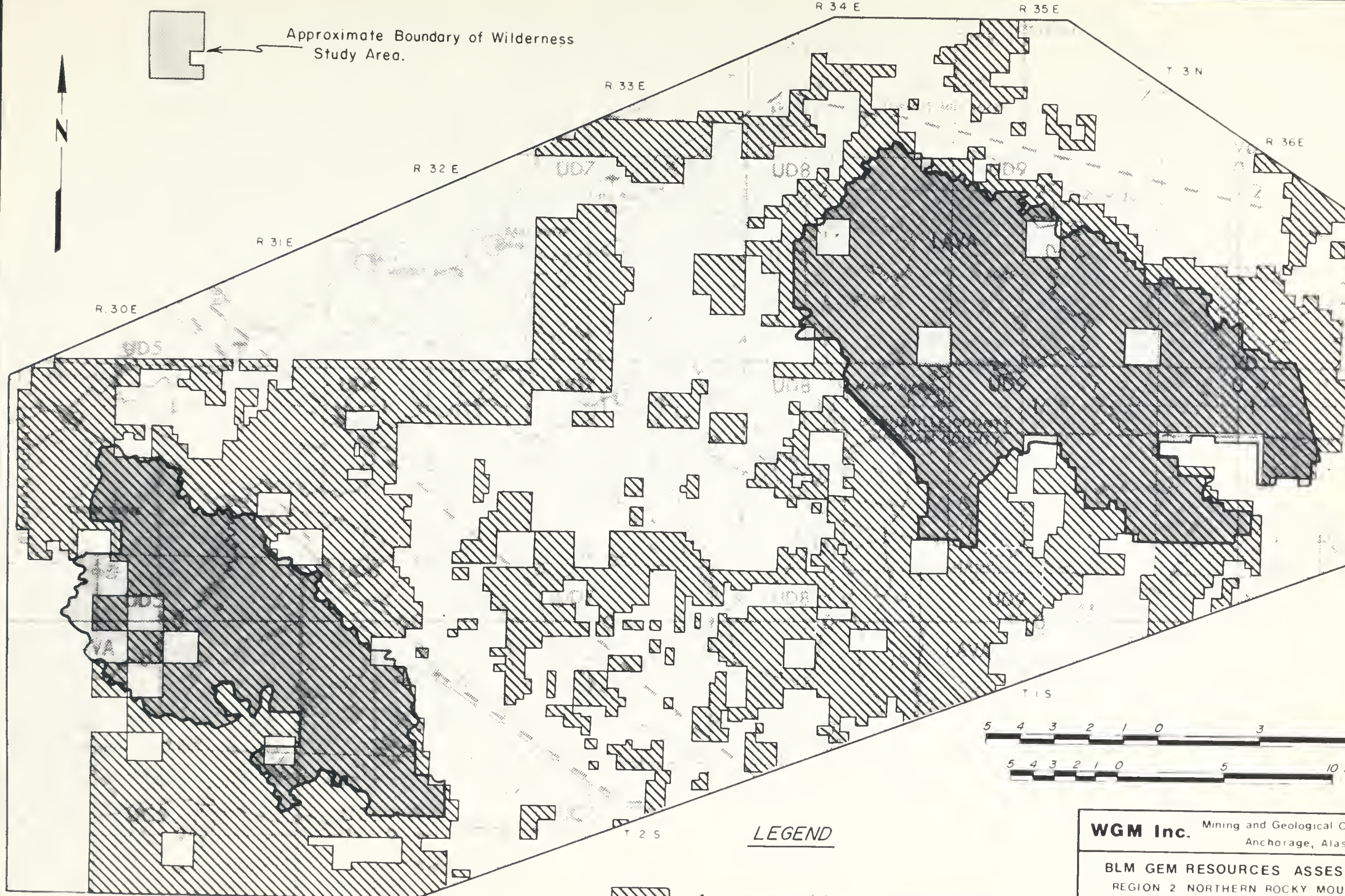
SCALE 1" = 45 MILES			FIGURE 12
DATA BY WGM	DATE 1/1983		
DRWN BY DSI	APPR. GF		

half to two thirds of the Lava GRA is covered by oil and gas leases (Fig. 13) including about 90% of the two WSAs.

3.4 Mineral and Energy Deposit Types

The absence of known metallic mineral deposits and occurrences in the Eastern Snake River Plain makes evaluation of the metallic mineral potential difficult. The potential of the Lava GRA must be evaluated by analogy and by comparison of the tectonic setting and geologic processes active in the area with those of similar mineralized areas. The Eastern Snake River Plain, as discussed earlier, can be described as a continental hot spot, rift zone or aulacogen. Most workers favor the mechanism described by Morgan (1972) and Burke and Dewey (1973) for the formation of the Plain by movement of a continental plate cover a fixed "hot spot" of rising mantle material (Smith and Christiansen, 1980).

The near-surface rocks of the Plain are subareal basalt flows which cover a series of rhyolitic calderas (Armstrong et al., 1975; Walker, 1964; Eaton et al., 1975; Christiansen and McKee, 1978; Mabey et al., 1978; Protska and Embree, 1978). The underlying rocks are rhyolitic flows and volcaniclastic caldera-fill deposits (Doherty et al., 1979). The volcanics have been intruded by rhyolitic to latitic plugs (Schoen, 1974; Spear, 1977, Kuntz, 1978a, b). Thus the gross tectonic setting comprising the Eastern Snake River Plain consists of three geologic environments: (1) subareal basalt flows; (2) rhyolitic calderas; and (3) felsic plutons.



LEGEND

Area covered by oil and gas leases.

Area covered by oil and gas lease application.

Notes: 1) Area of Search: Entire GRA
2) Data current to: Aug. 12, 1982
3) Source of Data: BLM Oil & Gas Lease Plats

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Lava GRA, Idaho

Oil and Gas Lease Status

SCALE 1" = 4 MILES			FIGURE
DATA BY WGM	DATE 1/1983	REVISED	13
DRWN BY DSI	APRVD G.F		

Mineral deposits associated with submarine basaltic volcanism along submarine rift zones such as the Red Sea and East Pacific Rise are well known. However, there are no known instances of metallic mineral deposits associated with the subareal basaltic volcanism of the Eastern Snake River Plain (Kuntz et al., 1980). The deposits in an oceanic setting are formed in hydrothermal systems involving convective circulation of seawater. The absence of hydrothermal activity in basaltic Plains volcanism (Greeley, 1977, 1982) apparently precludes formation of mineral deposits.

Mineralization of several types, including precious metal-rich veins (Lipman et al., 1976) and massive sulfide deposits (Hodgson and Lyden, 1977) are associated with caldera systems. The current hydrothermal activity in the Yellowstone Caldera indicates that similar processes may have been active in the older calderas buried beneath the basalt Plains (Smith and Christiansen, 1980). It is virtually impossible to evaluate the potential for mineralization in the buried calderas because of the thickness of the basalt cover. In addition the basalts have obscured most caldera-associated structures which could serve as hydrothermal conduits (Kuntz, 1978; Mabey, 1978; Protska and Embree, 1978).

In a recent review of the relationship of mineral deposits and tectonic settings Mitchell and Garson (1981) suggest that mineral deposits in rifted continental settings such as the Snake River Plain are mainly related alkaline intrusives and peraluminous granites. Deposits of tin, uranium and molybdenum could be expected in this environment (Mitchell and Garson, 1981). Rhyolitic and ferrolatite domes occur at Big Southern, East, Middle and Cedar Buttes in the Eastern Snake River Plain and are indicative of possibly more widespread intrusive activity. There are no reported occurrences of metallic mineral deposits at these domes. However, recent exploration work by AMAX Inc. at Big Southern Butte has resulted in discovery of subsurface stockwork molybdenum mineralization (S. Hamilton, pres. comm., 1982).

The silicic volcanics present in the subsurface of the Lava GRA are possible source rocks for uranium. These volcanics were sampled around the Island Park Caldera, about 50 miles to the northeast, by Suekawa et al. (1982). The rhyolite sample sites were concentrated along rim fractures of the caldera and were found to contain 2.0 to 12.0 ppm U_3O_8 and 10.0 to 40.0 ppm thorium. The thorium-to-uranium ratios are typical of original composition and do not indicate any uranium mobilization. Radiometric anomalies are associated with the volcanics, but no uranium occurrences were reported in the literature. Due to the lack of evidence of hydrothermal alteration and vein development and the overall absence of evidence that any concentrating processes have taken place, Suekawa et al. (1982) concluded that the Island Park Caldera is unfavorable for uranium deposits. No evidence exists to indicate that the silicic volcanics are present in the Lava GRA are more favorable than those around the Island Park Caldera for uranium deposits.

Building stone, cinder and common stone are the most abundant mineral resources in the Eastern Snake River Plain (Asher, 1965; Kuntz et al., 1980). Of these building stone is the most valuable. The best building stone is pahoehoe lava (Maley and Holland, 1981). Slab pahoehoe occurs mainly along flow margins and at the rims of lava lakes (Kuntz et al., 1980). Cinders occur in cinder cones, around the margins of Holocene lava flows and along rift zones (Kuntz et al., 1980; Asher, 1965).

In the most recent geothermal classification of the United States (Muffler, 1979), geothermal resources were divided into six categories. These are:

1. Conduction-dominated regions
2. Igneous-related geothermal systems

3a. High temperature (over 150°C) hydrothermal convection systems

b. Intermediate temperature (90-150°C) hydrothermal convection systems

4. Low temperature (less than 90°C) hydrothermal convection systems
5. Geo-pressured geothermal energy systems

For the purposes of this Wilderness Study Area Assessment these classes can be reduced to two: (1) high temperature (over 150°C) hydrothermal convection systems and low/intermediate temperature (40-150°C) hydrothermal convection systems. Geo-pressured geothermal energy systems do not exist in the area discussed. Theoretically geothermal resources exist everywhere because the temperature of the earth's crust everywhere increases with depth; thus, high temperatures are reached at some depth below any given point on the earth's surface. At the present time, and in the foreseeable future, a naturally occurring hot fluid coupled with sufficiently porous and permeable rocks to allow fluid migration are prerequisites for practical use of geothermal energy; thus, conduction-dominated and "magma-tap" geothermal systems are not included in this evaluation.

Western Montana and southern Idaho are included in the Cordilleran fold-thrust belt of western North America. Volcanic and tectonic processes have been active in these areas within the past few millions of years and there are extensive manifestations at the surface of geothermal resources. However, within this area there are quite significant geographic variations. Based on these geographic variations, the area within GEM Region 2 is divided into six geothermal provinces shown in Table IV below:

TABLE IV

GEOTHERMAL PROVINCES IN GEM REGION 2

1. Montana Thrust/Foothills
2. Montana Basin and Range
3. Central Idaho Basin and Range
4. Idaho Batholith/Blue Mountains
5. Southeastern Idaho Basin and Range
6. Snake River Plains

The Lava GRA is in the Snake River Plains geothermal province.

The volcanic history of the Snake River Plains geothermal province is quite varied and extends into the Holocene. Calderas in the Snake River Plains, most of which are now buried, were the source of extensive silicic ash flow tuffs which range in age from approximately 12 m.y. at the western edge of the Eastern Snake River Plains to an average of approximately 4 m.y. at the eastern margin of the Eastern Snake River Plains. Silicic volcanics are as young as 1.2 m.y. in the Island Park Caldera. In the middle of the Snake River Plains, the Big Southern Butte dome has been dated at approximately 300,000 years (Armstrong et al., 1975). Basaltic volcanic activity throughout the whole area has post-dated the silicic volcanic activity and has been continuous up into the Holocene. Large areas of the Eastern Snake River Plains are covered by basalts which are less than 10,000 years old (Greeley and King, 1977). So far there has been no deep drilling in the vicinity of any of these sites of Pleistocene and Holocene volcanism so the potential for geothermal resources is as yet unexplored.

The geothermal character of the Snake River Plain has been discussed by Mitchell et al. (1980) and by Brott et al. (1976, 1981). Surface evidence of any geothermal systems present would be oblituruated in much of the area the major, rapidly moving, ground water aquifer present in the Quaternary Snake River basalts which underlie up the surface in most of the Eastern Snake River Plain; therefore the geothermal character can only be evaluated by: (1) drilling beneath this aquifer, (2) making estimates of heat input into the aquifer, and (3) looking at the geochemical variations from place to place within the aquifer.

As yet exploration drilling in this area has been quite sparse. In the Eastern Snake River Plain only one deep hole, located within the Idaho National Engineering Laboratory test site, has been drilled (Walker, 1964). The bottom hole temperature at a depth of 9,845 feet was approximately 150°C. While there is evidence for circulation of water within the hole, economic quantities of fluid were not produced (Prestwich and Mink, 1979). A deep drill hole west of the Eastern Snake River Plains near the town of Mountain Home encountered temperatures of 190°C at a depth of 9,845 feet (Arney et al., 1981). It is not known whether the hole was capable of producing fluid because it was initially drilled as a hydrocarbon test.

There are numerous hot and warm springs and wells on both the north and south margins of the Snake River Plains where the geothermal systems are less diluted by the effects of the Snake Plain aquifer. In most areas where extensive drilling has been conducted, warm water has been discovered, but no economic high grade (greater than 150°C) geothermal systems have been located. However, in view of the extensive warm water occurrences in shallow wells, the demonstrated existence of such temperatures at depths of less than 9,845 feet, and the favorable volcanic history, it seems quite likely that in the future such systems will be discovered. Major areas of warm water occurrences along the north margin of the Snake River Plains are present near Magic Reservoir and near Arco. Along the southern margin extensive warm water resources occur near Rexburg and near Twin Falls.

The volcanic rocks which underlie the Lava GRA are not favorable source rocks for hydrocarbons although under some conditions they may act as reservoir rocks. Fluvial and lake sediments which are interbedded with the volcanic rocks (Walker, 1964) are potential source and reservoir units.

The Lava GRA lies on strike with the overthrust salient of the Cordilleran fold-thrust belt as defined by Blackstone (1977). Many similarities in thickness and lithology are present between Paleozoic strata exposed in mountain ranges north and south of the Snake River Plain. Geophysical studies also suggest that Paleozoic strata continue across or extend underneath the volcanics of the Snake River Plain from both the north and south (Stanley et al., 1977; Kuntz et al., 1980; Sparlin et al., 1982; Braile et al., 1982). These geophysical studies clearly show that several intervals of distinct rock types may be recognized under the Snake River Plain. Stanley et al. (1977) interpreted the third layer below the surface to represent the basement complex including sedimentary and metamorphic rock units. These are probably of Paleozoic and Mesozoic age. Strata overlying the basement complex and below the surficial volcanics are interbedded alluvial and fluvial clastics and volcanics (Walker, 1964; Stanley et al., 1977).

Should the thick paleozoic section described by Skipp and Hait (1977) extend under the Snake River Plains from the north and the thick Paleozoic and Mesozoic section described by Mansfield (1920) and Trimble and Carr (1976) extend under the Plain from the south, than the Paleozoic sections should interfinger and the Mesozoic section should thin or pinchout to the northwest. Both of the stratigraphic sections to the north and south of the Plain have recognized potential hydrocarbon source and reservoir beds in them. The dark shales of the Trail Creek, McGowan Creek and Phosphoria Formations are potential major hydrocarbon source beds and shaley limestones in the White Knob and Wood River Formations are potential minor hydrocarbon source beds north of the Plain. South of the Plain, the Phosphoria Formation and numerous Mesozoic dark shales are potential major source beds and shaley limestones of the Gallatin, Lodgepole and several Mesozoic formations are potential minor source beds of hydrocarbons. Extensive hydrocarbon potential studies made of the Phosphoria Formation (Claypool et al., 1978; Peterson, 1980) clearly show that it is a major hydrocarbon source bed throughout southeastern Idaho, western Wyoming and southwestern Montana. Approximately 50 miles northwest of the Lava GRA two samples of the McGowan Creek Formation from the White Knob and Lost River Ranges were analyzed for Nance Petroleum of Billings, Montana. These analyses reveal that the McGowan Creek Formation in those areas has a mature, very poor oil, good to excellent wet gas-condesate source character (pers. comm., November 1982). Potential hydrocarbon reservoir beds including fractured limestones, vuggy limestones and porous sandstones are also recognized both north and south of the Plain. These should also be present in the subsurface of the Lava GRA.

The presence of several volcanic vents considerably decreases the hydrocarbon potential within the Lava GRA. The extent of the metamorphism surrounding the vents and depth to the magmatic masses underlying the vents are unknown. The position of the magmatic masses can probably be determined by geophysical studies, but the extent of the metamorphism can only be determined by drilling.

3.5 Mineral and Energy Economics

The Lava GRA has adequate access and is near the major population centers of southern Idaho. Locally, power and water supplies are limited.

The only commodity mined in any quantity from the Lava GRA is lava rock (slab pahoehoe lava). Past production has been mainly from areas east of Idaho Falls from the Hell's Half Acre lava field. Carroll (1980) indicates that the slabs are broken or picked up at the removal site and loaded onto flatbed trucks, pickups or trailers. The product enjoys a close proximity to markets and is durable. However, the product has a high bulk density, haulage is hard on the haul trucks, and removal sites have physical and legal problems. Mining costs historically have been on the order of $45 per ton and the product retails at around $80 to $90 per ton (Carroll, 1980).

Based on present requirements for use of hot fluids in electrical generating techniques, geothermal systems with temperatures of less than 150°C do not have significant potential for electrical exploitation. These systems, however, can have a significant potential for low and intermediate temperature geothermal utilization for space heating, material processing, etc. if their minimum temperature exceeds 40°C. At the lower end of the spectrum, as the energy content of the resource becomes less, or the drilling depth necessary for exploitation becomes greater, there is a very ill-defined cutoff. For example, shallow ground water temperatures on the order of 10-20°C can be used for heat pump applications, and in some cases these are considered geothermal resources. However, for the purpose of this evaluation, a lower temperature than approximately 40°C is considered an economic cutoff for a geothermal resource. Another important economic factor affecting the viability of a geothermal resource is the distance from the source to the point of consumption. At lower temperatures it is not feasible to consider long-distance transportation of geothermal energy whereas for electrical grade resources long transportation distances are of course feasible. The presence of developments within and adjacent to the GRA would ensure that geothermal resources, even low temperature ones, would be exploited.

4.0 LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

4.1 Explanation of Classification Scheme

In the following sections the land in the Lava GRA is classified for geology, energy and mineral (GEM) resources potential. The classification scheme used is shown in Table V. Use of this system is specified in the contact under which WGM prepared this report.

The evaluation of resource potential and integration into the BLM classification system has been done using a combination of simple subjective and complex subjective approaches (Singer and Mosier, 1981) to regional resource assessment. The simple subjective approach involves the evaluation of resources based on the experience and knowledge of the individuals conducting the evaluations. The complex subjective method involves use of rules, i.e. geologic inference, based in expert opinion concerning the nature and importance of geologic relationships associated with mineral and energy deposits (Singer and Mosier, 1981).

The GEM evaluation is the culmination of a series of tasks. The nature and order of the tasks was specified by the BLM, however they constitute the general approach by which most resource evaluations of this type are conducted. The sequence of work was: (1) data collection, (2) compilation, (3) evaluation, and (4) report preparation. No field work was done in the Lava GRA.

TABLE V

BUREAU OF LAND MANAGEMENT GEM RESOURCES LAND CLASSIFICATION SYSTEM

CLASSIFICATION SCHEME	LEVELS OF CONFIDENCE
1. The geologic environment and the inferred geologic processes do not indicate favorability for accumulation of mineral resources.	A. The available data are either insufficient and/or cannot be considered as direct evidence to support or refute the possible existence of mineral resources within the respective area.
2. The geologic environment and the inferred geologic processes indicate low favorability for accumulation of mineral resources.	B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.
3. The geologic environment, the inferred geologic processes, and the reported mineral occurrences indicate moderate favorability for accumulation of mineral resources.	C. The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.
4. The geologic environment, the inferred geologic processes, the reported mineral occurrences, and the known mines or deposits indicate high favorability for accumulation of mineral resources.	D. The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

Each WSA is classified for locatable, leasable, and saleable resources potential.

Locatable minerals are those which are locatable under the General Mining Law of 1872, as amended, and the Placer Act of 1870, as amended. Minerals which are locatable under these acts include metals, ores of metals, non-metallic minerals such as asbestos, barite, zeolites, graphite, uncommon varieties of sand, gravel, building stone, limestone, dolomite, pumice, pumicite, clay, magnesite, silica sand, etc. (Maley, 1983).

Leasable resources include those which may be acquired under the Mineral Leasing Act of 1920 as amended by the Acts of 1927, 1953, 1970, and 1976. Materials covered under this Act include: asphalt, bitumen, borates of sodium and potassium, carbonates of sodium and potassium, coal, natural gas, nitrates of sodium and potassium, oil, oil shale, phosphate, silicates of sodium and potassium, sulfates of sodium and potassium, geothermal resources, etc. (Maley, 1983).

Saleable resources include those which may be acquired under the Materials Act of 1947 as amended by the Acts of 1955 and 1962. Included under this Act are common varieties of sand, gravel, stone, cinders, pumice, pumicite, clay, limestone, dolomite, peat and petrified wood (Maley, 1983).

4.2 Classification of the Cedar Butte (33-4) WSA

4.2.1 Locatable Minerals

4.2.1a Metallic Minerals. The Cedar Butte (33-4) WSA (1a, Fig.14) is classified as unfavorable for metallic mineral resources based on direct but minimal evidence (1C). The basis of this classification is data and concepts outlined in Section 3.0.

4.2.1b Uranium and Thorium. All of the Cedar Butte (33-4) WSA (1b, Fig. 14) is classified as unfavorable for uranium and thorium resources based on direct but minimal evidence (1C). The basis of this classification is data and concepts outlined in Section 3.0.

4.2.1c Non-Metallic Minerals. Cedar Butte (33-4) WSA (1c-sl, Fig. 14) is classied as highly favorable for slab lava resources based on abundant direct evidence (4D). Areas along the edge of the Cerra Grande Lava flow would be most likely to be developed first due to more favorable access. The basis of this classification is the history past of production from the lava field and other similar young flows. The entire area of the Cedar Butte (33-4) WSA (1c-other, Fig. 14) is classified as unfavorable for accumulation of other non-metallic resources based on direct but minimal data (1C). The basis of the classification is data and concepts outlined in Section 3.0.

Lava GRA, Idaho
Legend For Figure 14

BLM LAND CLASSIFICATION SYSTEM FOR GEM RESOURCES

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

LEVELS OF CONFIDENCE

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVLEY MINIMAL TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

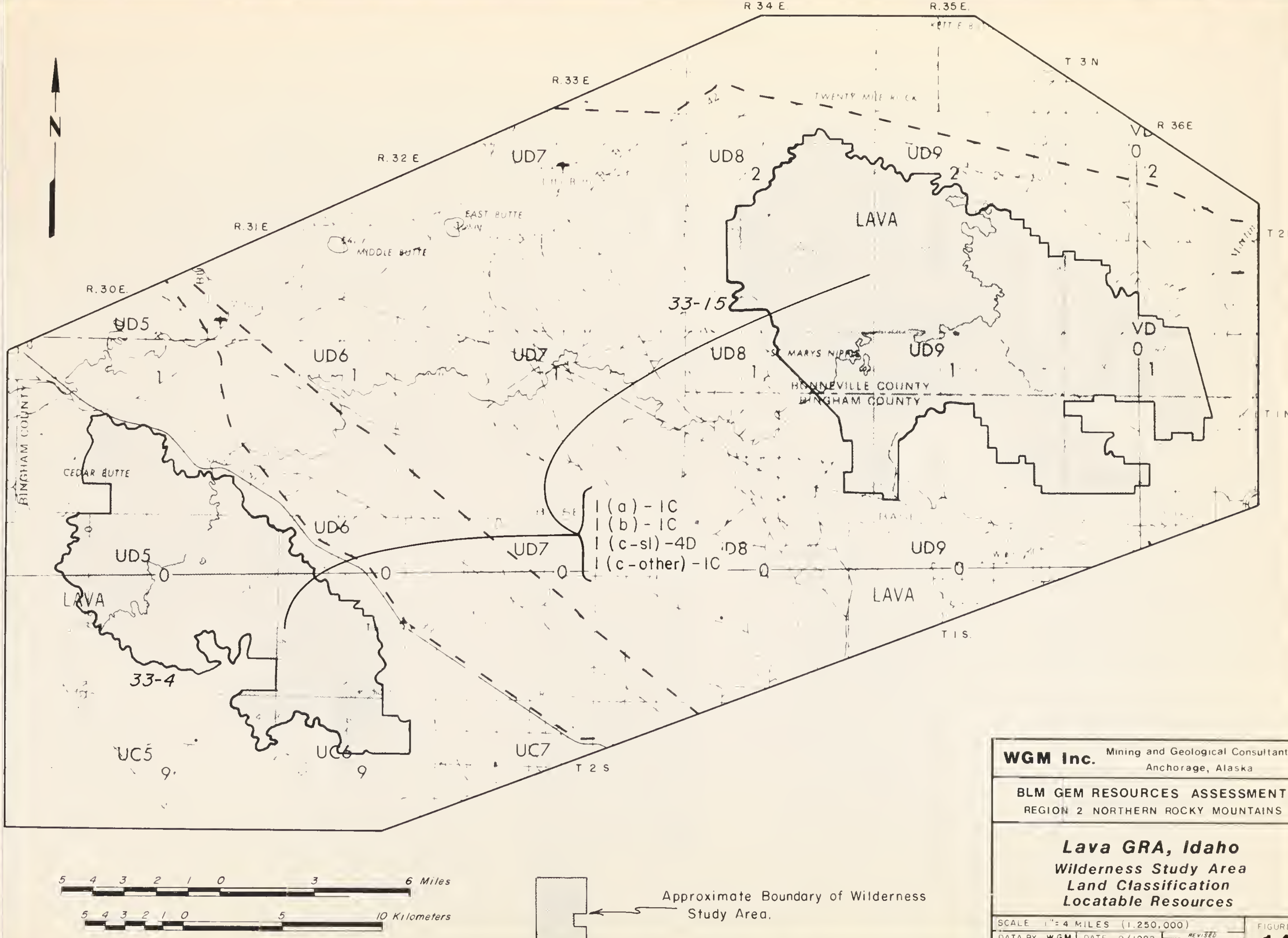
D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

EXPLANATION

1(a) - 4D

- 1 — Area I.D. Number
- (a) — Commodity
- 4 — Classification
- D — Level of Confidence

a) Metallic Minerals
b) Uranium and Thorium
c) Non-Metallic Minerals



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Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Lava GRA, Idaho

Wilderness Study Area
Land Classification
Locatable Resources

SCALE 1" = 4 MILES (1:250,000)		REVISED	FIGURE
DATA BY WGM	DATE 9/1982		14
DRWN BY DSI	APRVD GF		

4.2.2 Leasable Resources

4.2.2a Oil and gas. The entire Cedar Butte (33-4) WSA (1a, Fig. 15) is classified as having low favorability for accumulation of hydrocarbon resources based on indirect evidence (2B). The classification is based on data and concepts outlined in Section 3.4.

4.2.2b Geothermal. The Cedar Butte (33-4) WSA (1b, Fig. 15) is classified as having low favorability with respect to low/intermediate temperature geothermal resources based on indirect evidence (2B) and as having low to moderate favorability for high temperature geothermal resources based on an inadequate amount of data (2A to 3A).

4.2.2c Sodium and Potassium. The entire area of Cedar Butte (33-4) WSA (1c, Fig. 15) is classified as unfavorable for accumulation of sodium and potassium resources based on minimal data (1A). The geologic environment, thickness of basalt, high ground water charge rate, and lack of occurrences is the basis of the classification.

4.2.2d Other. The Cedar Butte (33-4) WSA (1d, Fig. 15) is classified as having a low favorability for accumulation of other leasable resources based on minimal data (2A). Phosphate- or asphalt/bitumen-bearing beds may be present at great depth below the volcanics. The great depth would likely prohibit development of any such commodities.

Lava GRA, Idaho
Legend For Figure 15

BLM LAND CLASSIFICATION SYSTEM FOR GEM RESOURCES

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRCNMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

LEVELS OF CONFIDENCE

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVLEY MINIMAL TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

EXPLANATION

Area I.D. Number

I(a)- 4D

Level of Confidence

Commodity

Classification

a) oil and gas

b) Geothermal: high temperature (H), Low temperature (L)

c) Sodium and Potassium

d) others: Asphalt (As) bitumen (bt), phosphate (ph), No specific commodity designation indicates that the rating applies to all of the above.

4.2.3 Saleable Resource

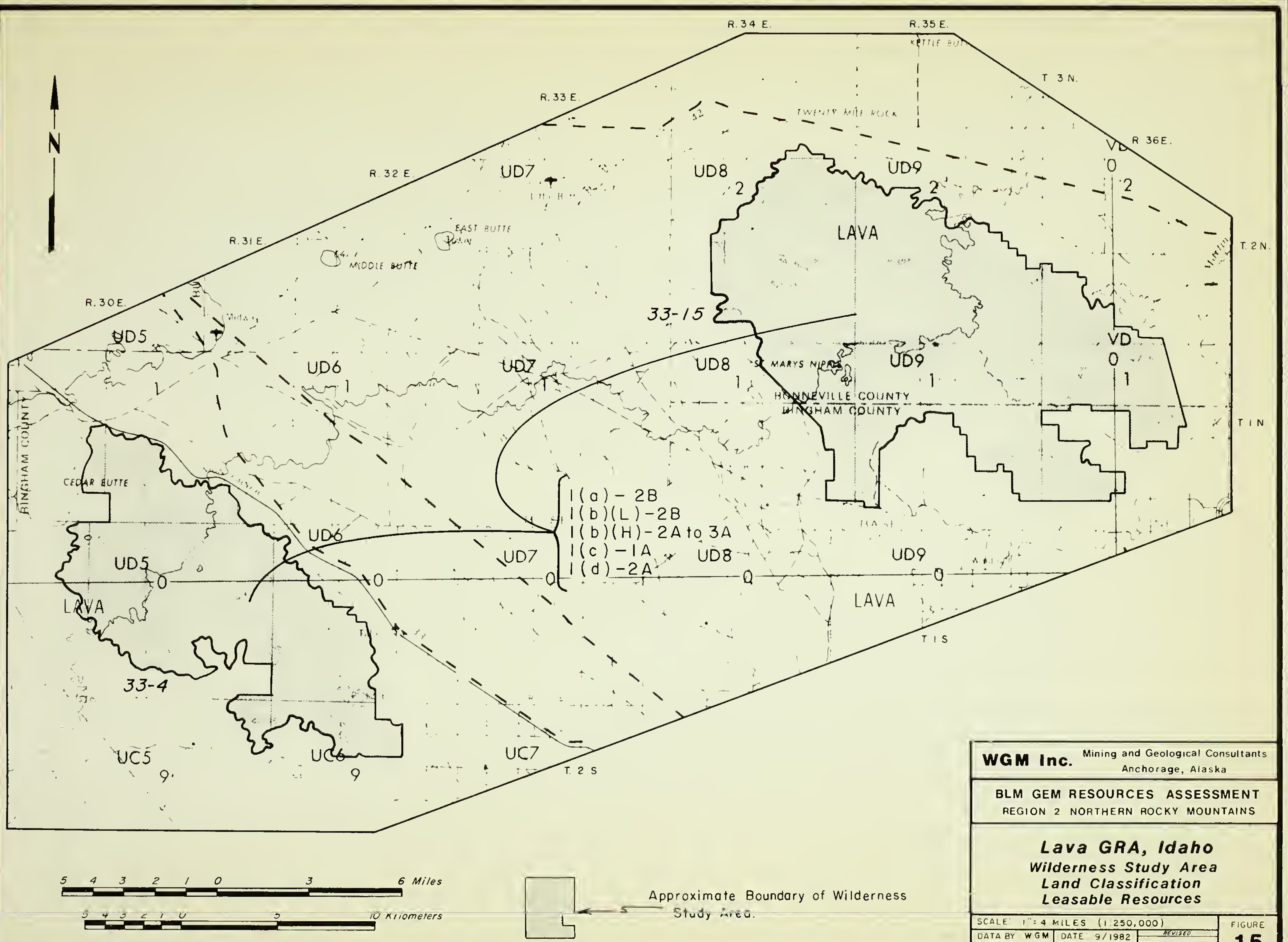
The entire Cedar Butte (35-4) WSA (1c-p, Fig. 16) is classified as highly favorable for cinder and pumice resources based on abundant direct evidence (4D). Vent areas within the lava fields are more favorable sites for accumulation of cinders and pumice than other areas within the lava field. The classification is based upon the favorable geology and the presence of known deposits in the area. The Cedar Butte (35-4) WSA (1-others, Fig. 16) is classified as unfavorable for other saleable resources based on direct but minimal data (1C). The classification is based upon the youth of the volcanics which underlie the WSA and on concepts and data outlined in Section 3.0.

4.3 Classification of the Hell's Half Acre (33-15) WSA

4.3.1 Locatable Minerals

4.3.1a Metallic Minerals. All of Hell's Half Acre (33-15) WSA (1a, Fig. 14) is classified as unfavorable for metallic mineral resources based on direct but minimal evidence (1C). The basis of this classification is data and concepts outlined in Section 3.0.

4.3.1b Uranium and Thorium. Hell's Half Acre (33-15) WSA (1b, Fig. 14) is classified as unfavorable for uranium and thorium resources based on direct but minimal evidence (1C). The basis of this classification is data and concepts outlined in Section 3.0.



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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Lava GRA, Idaho
Wilderness Study Area
Land Classification
Leasable Resources

SCALE: 1" = 4 MILES (1:250,000)			FIGURE
DATA BY WGM	DATE 9/1982	REVISED	15
DRWN BY DSI	APRVD G.F.		

Lava GRA, Idaho
Legend For Figure 16

BLM LAND CLASSIFICATION SYSTEM FOR GEM RESOURCES

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

LEVELS OF CONFIDENCE

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVLEY MINIMAL TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

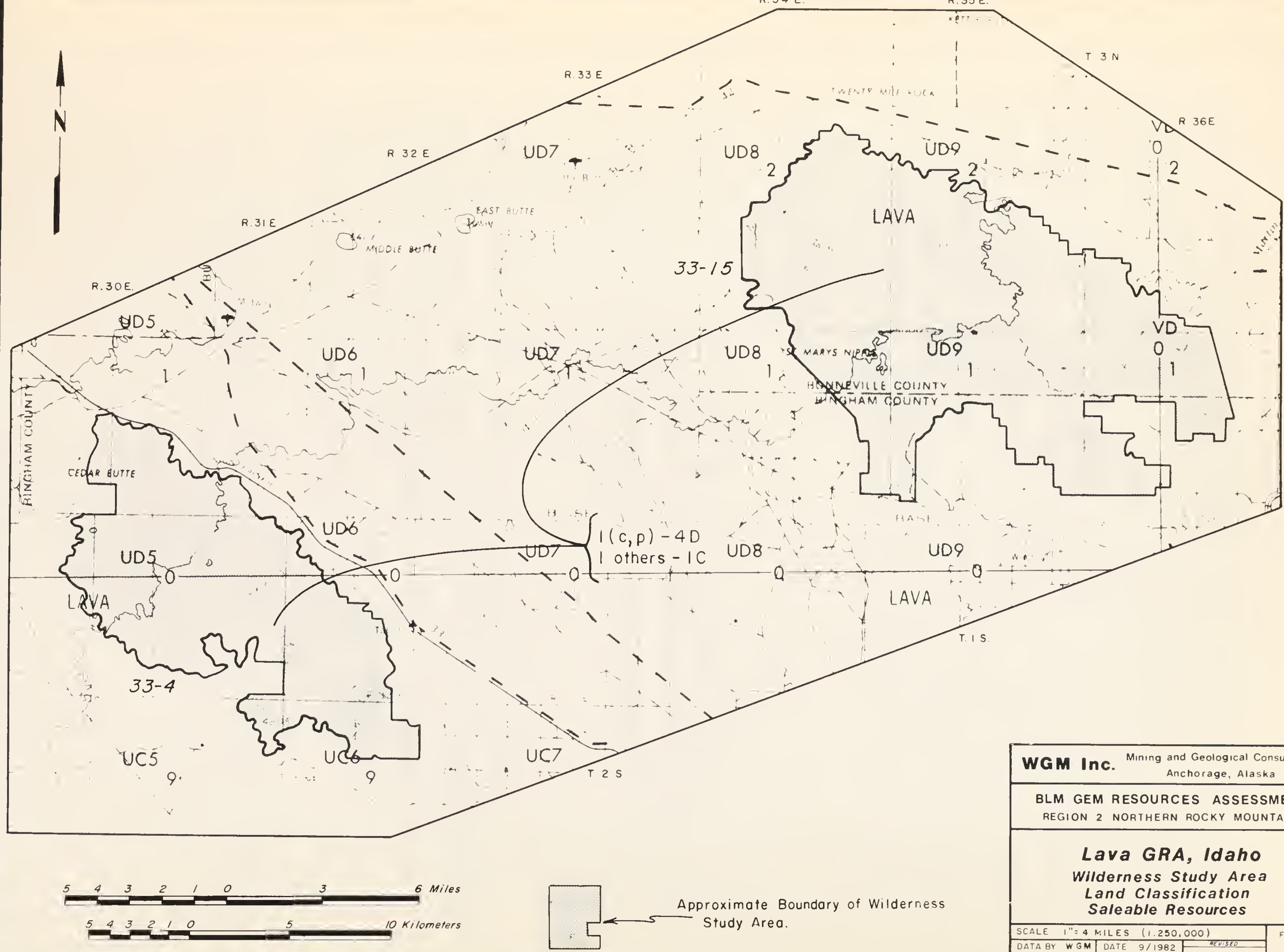
EXPLANATION

Area I.D. Number

i(1s)- 4D

ommodity — Classification — Level of Confidence

s	Sand
g	Gravel
st	Stone
c	Cinders
p	Pumice
pt	Pumicite
cl	Clay
Ls	Limestone
dl	Dolomite
P	Peat
pw	Petrified wood



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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Lava GRA, Idaho
Wilderness Study Area
Land Classification
Saleable Resources

SCALE 1"= 4 MILES (1:250,000)		FIGURE
DATA BY WGM	DATE 9/1982	REVISED
DRWN BY DS1	APRVD G.F	16

4.3.1c Non-Metallic Minerals. Hell's Half Acre (33-15) WSA (1c-sl, Fig. 13) is classified as highly favorable for slab lava resources based on abundant direct evidence (4D). Areas along the edge of the Cerra Grande Lava flow would be most likely to be developed first due to more favorable access. The basis of this classification is the history of past production from the lava field and other similar young flows. Hell's Half Acre (33-15) WSA (1c-other, Fig. 14) is classified as unfavorable for accumulation of other non-metallic resources based on direct but minimal data (1C). The basis of the classification is data and concepts outlined in Section 3.0.

4.3.2 Leasable Resources

4.3.2a Oil and Gas. The entire Hell's Half Acre (33-15) WSA (1a, Fig. 15) is classified as having low favorability for the accumulation of hydrocarbon resources based on indirect evidence (2B). The classification is based on data and concepts outlined in Section 3.4.

4.3.2b Geothermal. Hell's Half Acre (33-15) WSA (1b, Fig. 15) is classified as having low favorability for the occurrence of low/intermediate temperature geothermal resources based on indirect evidence (2B) and as having low to moderate favorability for high temperature geothermal resources based on an inadequate amount of data (2A to 3A).

4.3.2c Sodium and Potassium. The entire Hell's Half Acre (33-15) WSA (1c, Fig. 15) is classified as unfavorable for the accumulation of sodium and potassium resources based on inadequate data (1A). The geologic environment, thickness of the basalts, high ground water charge rate, and lack of occurrences is the basis of the classification.

4.3.2d Other. Hell's Half Acre (33-15) WSA (1d, Fig. 15) is classified as having a low favorability for accumulation of other leasable resources based on inadequate data (2A). Phosphate- or asphalt/bitumen-bearing beds may be present at great depth below the volcanics, but the depths would likely prohibit development of any such commodities.

4.3.3 Saleable Resources

The Hell's Half Acre (35-15) WSA (1c-p, Fig. 16) is classified as highly favorable for cinder and pumice resources based on abundant direct evidence (4D). Vent areas within the lava fields are more favorable sites for accumulation of cinder and pumice than other areas within the lava fields. The classification is based upon the favorable geology and the presence of known deposits in the area. The Hell's Half Acre (35-15) WSA (1-others, Fig. 16) is classified as unfavorable for other saleable resources based on direct but minimal data (1C). The classification is based upon the youth of the volcanics which underlie the WSA and on concepts and data outlined in Section 3.0.

5.0 RECOMMENDATIONS FOR FURTHER WORK

To further evaluate slab lava resources within the Cedar Butte (33-4) and Hell's Half Acre (33-15) WSAs will require geologic mapping to define slab-pahoehoe lavas.

The hydrocarbon potential of the Lava GRA can be further evaluated by completion of the following recommendations:

1. Detailed geophysical studies in the Eastern Snake River Plain should be continued. These surveys will result in the recognition of sub-surface structures that could be potential hydrocarbon reservoirs.

2. Hydrocarbon characterization and thermal maturity studies should be made of potential source beds on both sides of the Snake River Plain since these same units are believed to extend beneath the Plain. These investigations will identify the type of hydrocarbons to be expected in the area and delineate those horizons where burial depths have removed hydrocarbons.

3. One or two deep tests need to be drilled in the Snake River Plain. These tests would provide data to verify geophysical interpretations of the deeper structures and stratigraphy. They would also give some indication of the extent of metamorphism surrounding the volcanic vents. Potential hydrocarbon source and reservoir beds could also be evaluated by a test well.

Direct evaluation of the geothermal potential will be very difficult and expensive given the nature of the terrain and the possible target depths. Deep drilling supplemented by a deep-seeking resistivity survey are the only practical ways to approach the evaluation. Electromagnetic techniques used to look for conductors below the high resistivity basalts of the Snake Plain Aquifer could also be used. The presence of a conductor would not necessarily mean geothermal potential, however, and drilling would be required to identify the geothermal significance of any conductive anomaly located.

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